

# **THE LARGE MARINE ECOSYSTEM APPROACH TO THE ASSESSMENT AND GOVERNANCE OF OCEAN COASTAL RESOURCES, WITH APPLICATIONS TO THE NORTHEAST SHELF LME**

NOAA Regional Delineation Workshop  
Charleston, South Carolina  
31 August to 1 September 2004

# 1992 UNCED Declaration

12

## **UNCED DECLARATION ON THE OCEANS RECOMMENDED THAT NATIONS:**

**Prevent, reduce, and control degradation of the marine environment so as to maintain and improve its life-support and productive capabilities**

**Develop and increase the potential of marine living resources to meet human nutritional needs, as well as social, economic, and development goals**

**Promote the integrated management and sustainable development of coastal areas and the marine environment**

# **Selected, Ecosystem Related WSSD Targets and Program of Action (POI) Johannesburg, August 2002**

- **Land-based Sources of Pollution**  
**POI – Substantially reduce by 2006**
- **Ecosystem-based Approach**  
**POI – Introduce by 2010**
- **Marine Protected Areas**  
**POI - Designated Network by 2012**
- **Restoration and Sustainability of Fisheries**  
**POI – On an urgent basis and where  
possible to MSY by 2015**

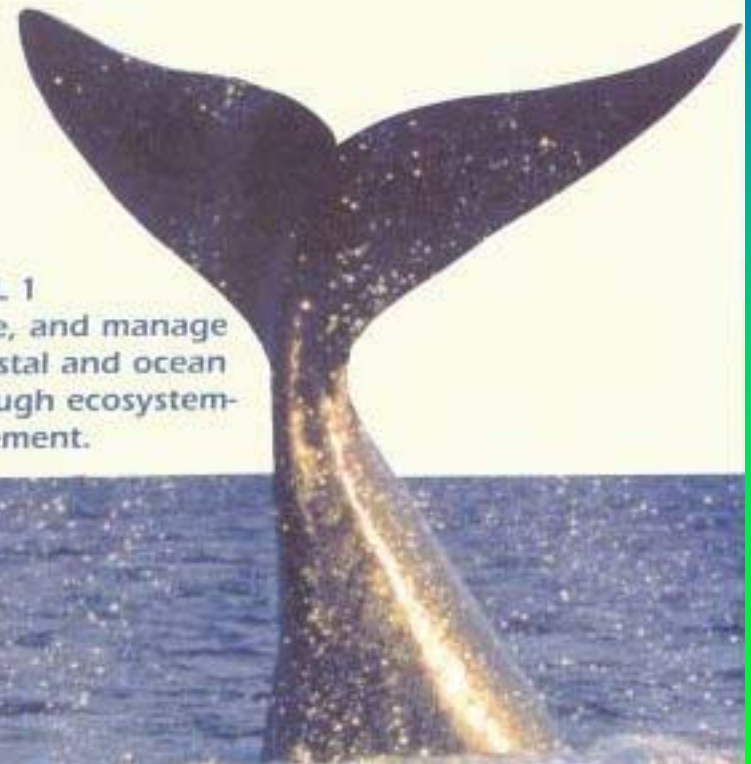
# NOAA MISSION GOAL 1: 2003 to 2008

## ECOSYSTEMS

Coastal areas are among the most developed in the Nation. Our coastal counties are growing three times faster than other U.S. counties, adding more than 3,600 people a day to their populations. During the first decade of the 21st century, the greatest challenge will be to implement a truly integrated ecosystem management approach to all of NOAA's living resource responsibilities by all NOAA components.

Within this context, NOAA is working with its partners to achieve a balance between the use and protection of coastal and marine resources to ensure their health, sustainability, and vitality for today's and tomorrow's generations. Our primary focus will be rebuilding fisheries and recovery of protected species.

**MISSION GOAL 1**  
Protect, restore, and manage  
the use of coastal and ocean  
resources through ecosystem-  
based management.



# Building Ocean Policy on Sound Guiding Principles

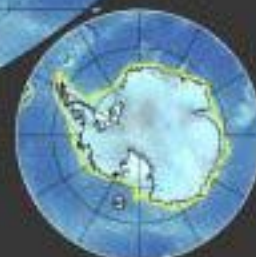
- Ecosystem-based Management: U.S. ocean and coastal resources should be managed to reflect the relationships among all ecosystem components, including humans and nonhuman species and the environments in which they live. Applying this principle will require defining relevant geographic management areas based on ecosystem, rather than political, boundaries.

# **ECOLOGICAL CRITERIA USED TO DETERMINE AREAL EXTENT OF LMES:**

- **Bathymetry**
- **Hydrography**
- **Productivity**
- **Trophodynamics**

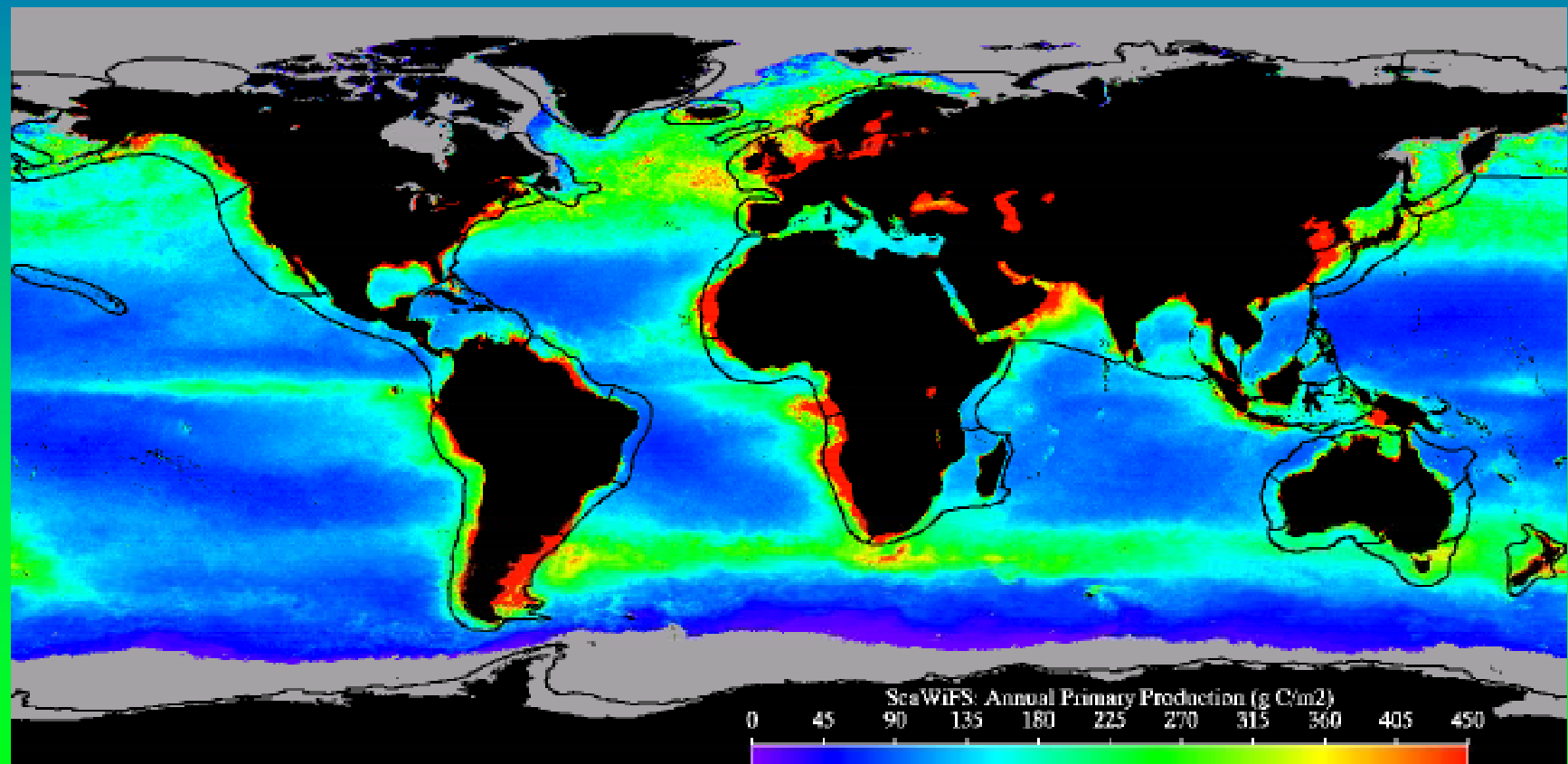


*Large Marine Ecosystems of the World  
and Linked Watersheds*



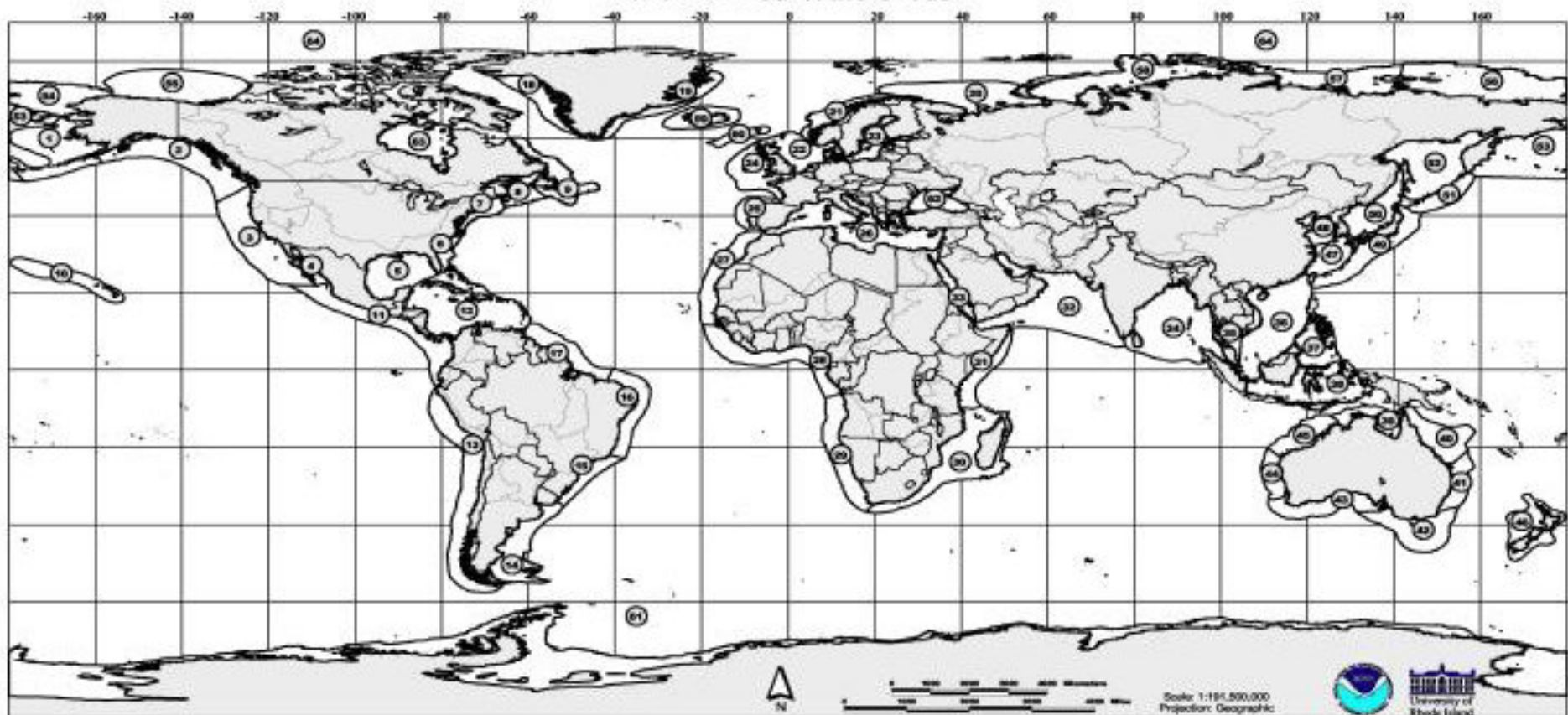
For More Information Visit: [www.educationline](http://www.educationline)

## 95% of the World's Annual Marine Fishery Catches are Produced in 64 LMEs





# Large Marine Ecosystems of the World with Linked Watersheds



1. East Bering Sea
2. Gulf of Alaska
3. California Current
4. Gulf of California
5. Gulf of Mexico
6. Southeast U.S. Continental Shelf
7. Northeast U.S. Continental Shelf
8. Scotian Shelf
9. Newfoundland-Labrador Shelf
10. Insular Pacific-Hawaiian
11. Pacific Central-American
12. Caribbean Sea
13. Humboldt Current

14. Patagonian Shelf
15. South Brazil Shelf
16. East Brazil Shelf
17. North Brazil Shelf
18. West Greenland Shelf
19. East Greenland Shelf
20. Barents Sea
21. Norwegian Shelf
22. North Sea
23. Baltic Sea
24. Celtic-Biscay Shelf
25. Iberian Coastal
26. Mediterranean

27. Canary Current
28. Guinea Current
29. Benguela Current
30. Agulhas Current
31. Somali Coastal Current
32. Arabian Sea
33. Red Sea
34. Bay of Bengal
35. Gulf of Thailand
36. South China Sea
37. Sulu-Celebes Sea
38. Indonesian Sea
39. North Australia

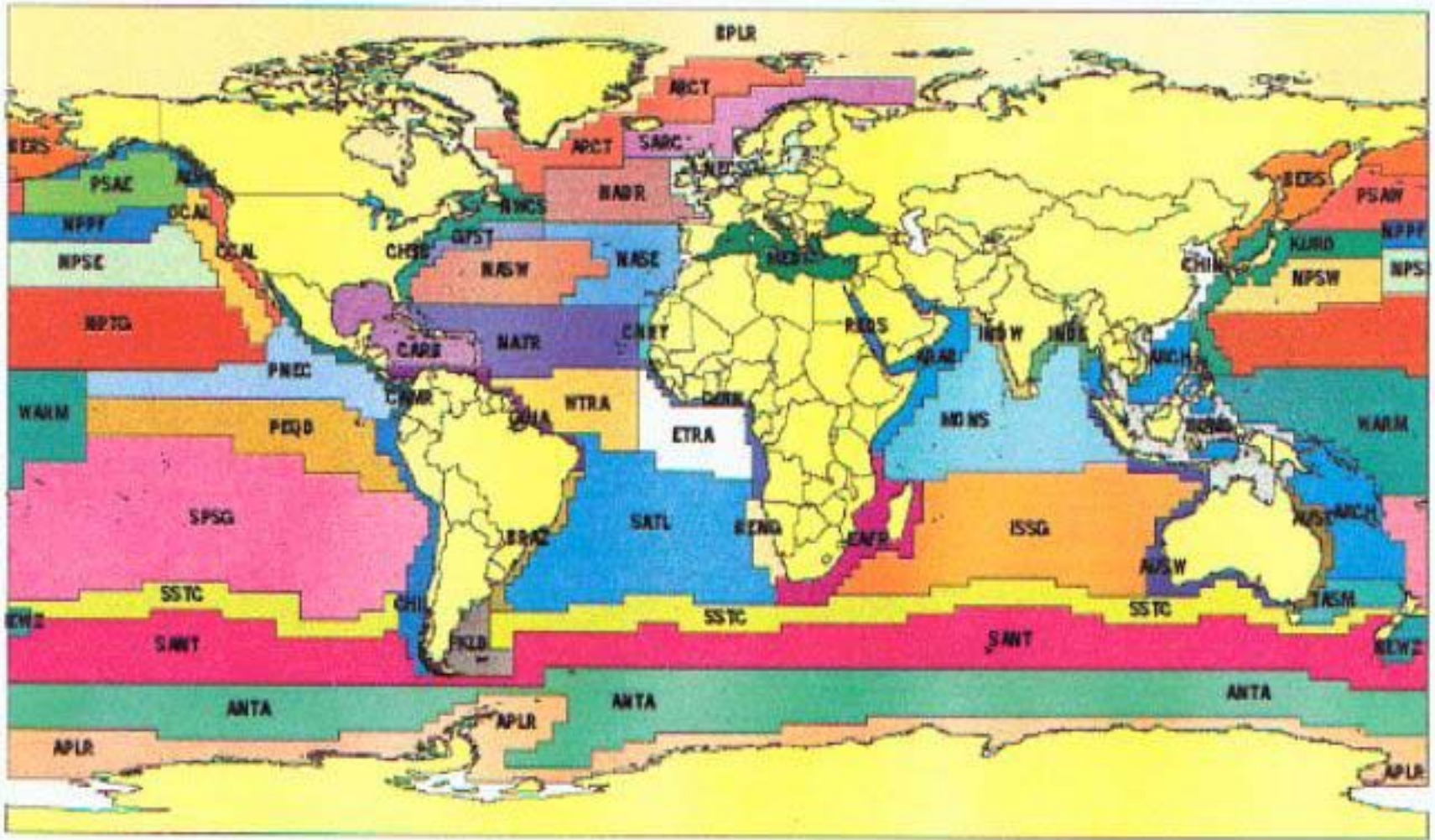
40. Northeast Australia
41. East-Central Australia
42. Southeast Australia
43. Southwest Australia
44. West-Central Australia
45. Northwest Australia
46. New Zealand Shelf
47. East China Sea
48. Yellow Sea
49. Kuroshio Current
50. Sea of Japan
51. Oyashio Current
52. Sea of Okhotsk

53. West Bering Sea
54. Chukchi Sea
55. Beaufort Sea
56. East Siberian Sea
57. Laptev Sea
58. Kara Sea
59. Iceland Shelf
60. Faroe Plateau
61. Antarctic
62. Black Sea
63. Hudson Bay
64. Arctic Ocean

Scale: 1:191,500,000  
Projection: Geographic



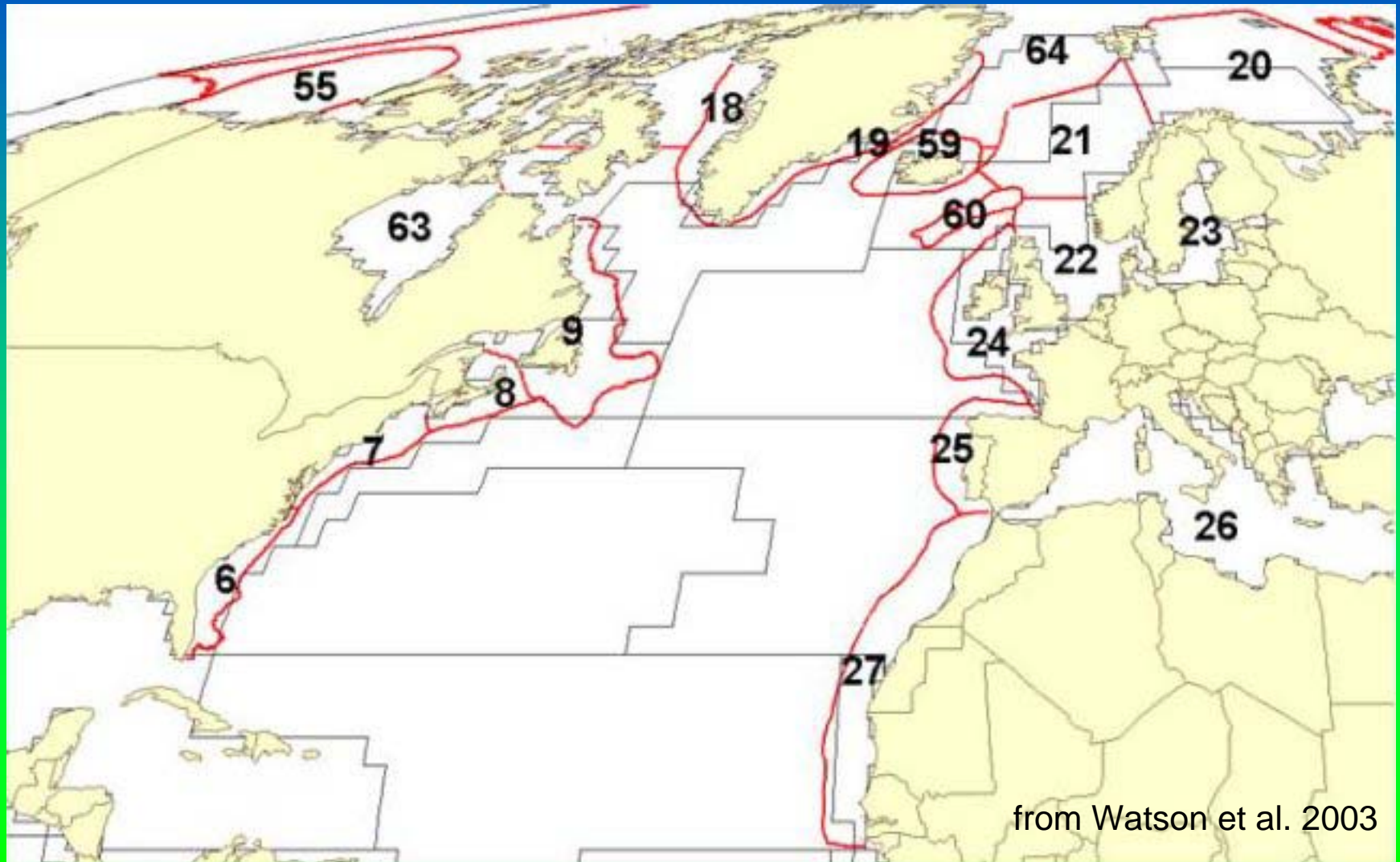
# 57 Biogeochemical Provinces



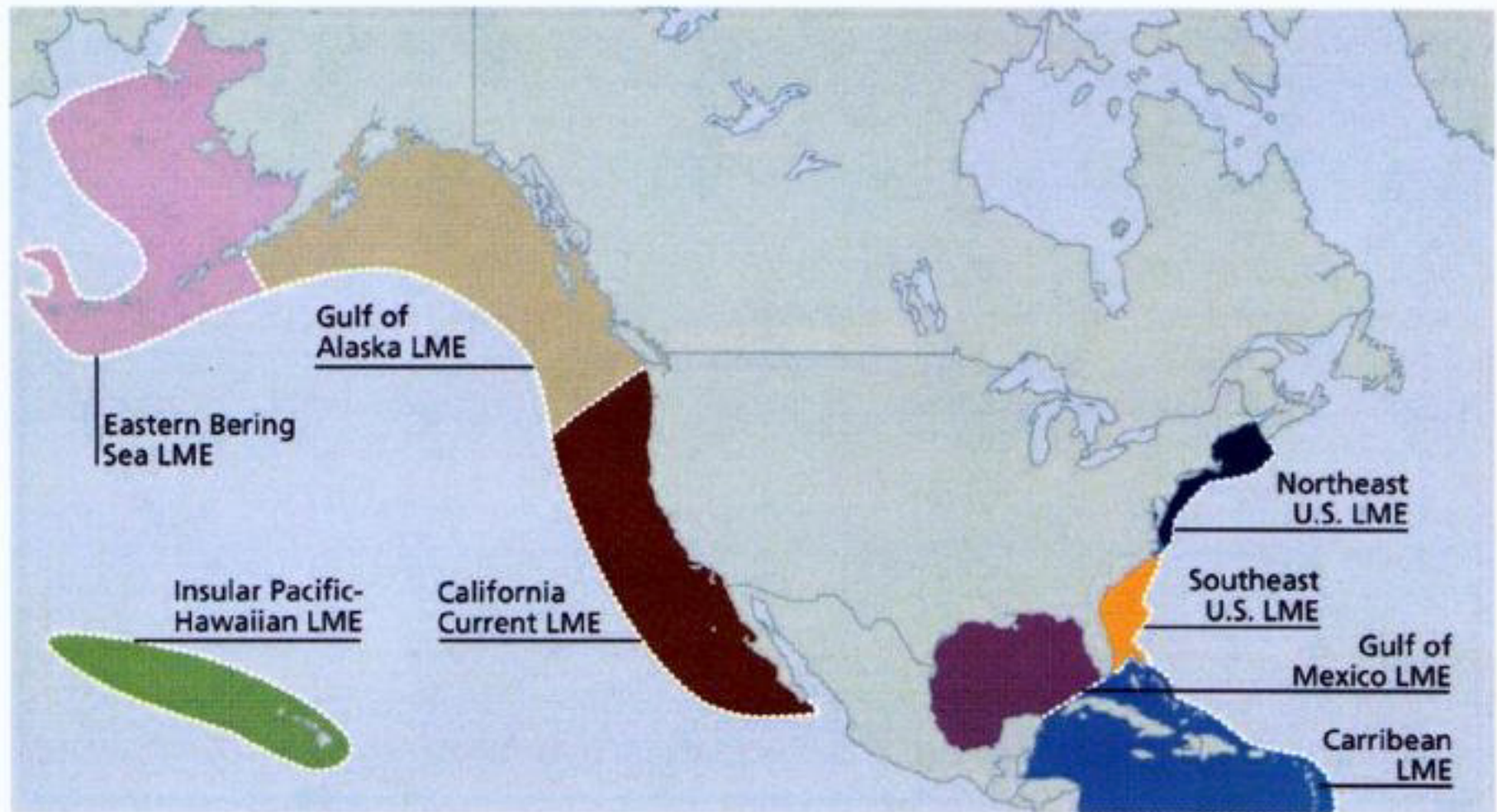
from Watson et al. 2003



# Congruities between Coastal Biome Biogeochemical Provinces (BGCPs designated by straight lines) and LMEs (numbered)

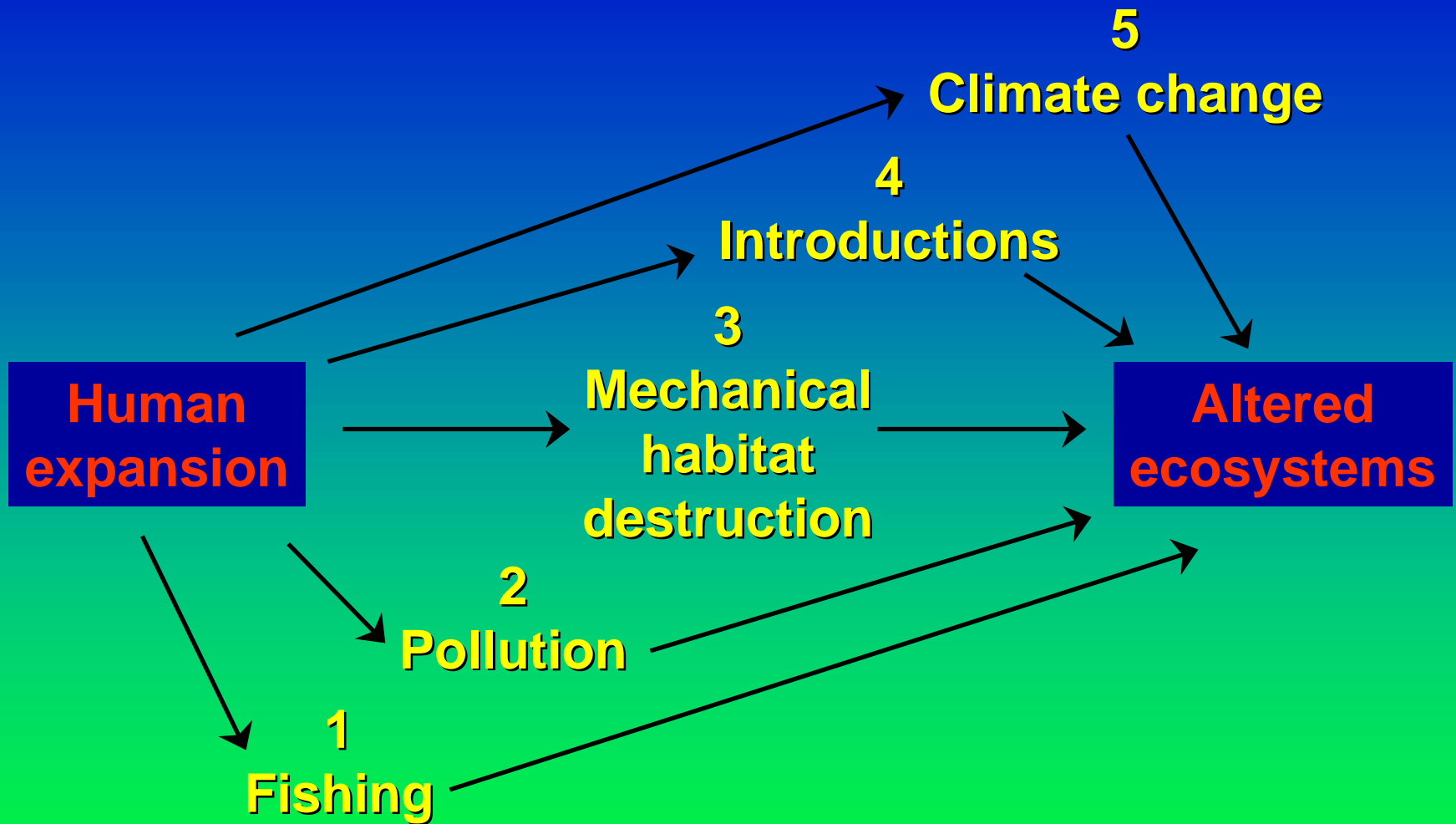


**Figure 3.1. Large Marine Ecosystems Correspond to Natural Features**



As the map indicates, eight large marine ecosystems (LMEs) have been identified for the United States. These LMEs are regions of the ocean encompassing coastal areas out to the seaward boundaries of continental shelves and major current systems and take into account the biological and physical components of the marine environment as well as terrestrial features, such as river basins and estuaries, that drain into these ocean areas.

Source: University of Rhode Island Environmental Data Center, Department of Natural Resources  
<<http://mapper.edc.uri.edu/website/lmeims/viewer.htm>> (Accessed January, 2004).



***“Then”*** ..... ***“Now”***

# Funding support from the Global Environment Facility, for projects linking environmental protection to resource development and sustainability

First tranche of projects:

Supported at \$2.1 billion funding level, 1994-1998

Second tranche of projects: supported at \$2.7 billion funding level, 1999-2002

Third tranche of projects: supported at \$3.0 billion funding level, 2002-2005

**Categories for funding include:**

- Global climate change (ozone)
- Biodiversity
- International waters



121 Developing Countries  
Participate in LME Assessment and  
Management Projects in Africa,  
Asia, Latin America and Eastern  
Europe.

GEF and Country Investment in  
Projects as of January 2004 = \$650  
million.

# LMEs ARE GLOBAL CENTERS OF EFFORTS TO:

- **REDUCE** coastal pollution
- **RESTORE** damaged habitats  
(Coral reefs, mangroves, sea grasses)
- **RECOVER** depleted fishery stocks

# GEF International Waters Operational Strategy

Supports  
New  
Paradigm



- Ecosystem-based  
LME Restoration  
Actions

- TDA/SAP  
Priority Actions

# Modular Assessments

## Support LME Restoration and Sustainable Development



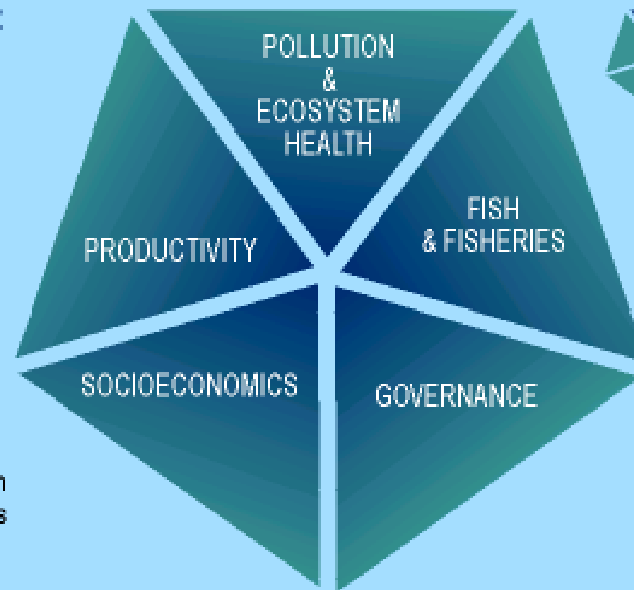
### PRODUCTIVITY MODULE INDICATOR

Photosynthetic activity  
Zooplankton biodiversity  
Oceanographic variability



### SOCIOECONOMIC MODULE INDICATOR

Integrated assessments  
Human forcing  
Sustainability of long-term socioeconomic benefits



### POLLUTION & ECOSYSTEM HEALTH MODULE INDICATOR

Eutrophication  
Biotoxins  
Pathology  
Emerging disease  
Health indices



### FISH & FISHERIES MODULE INDICATOR

Biodiversity  
Finfish  
Shellfish  
Demersal species  
Pelagic species

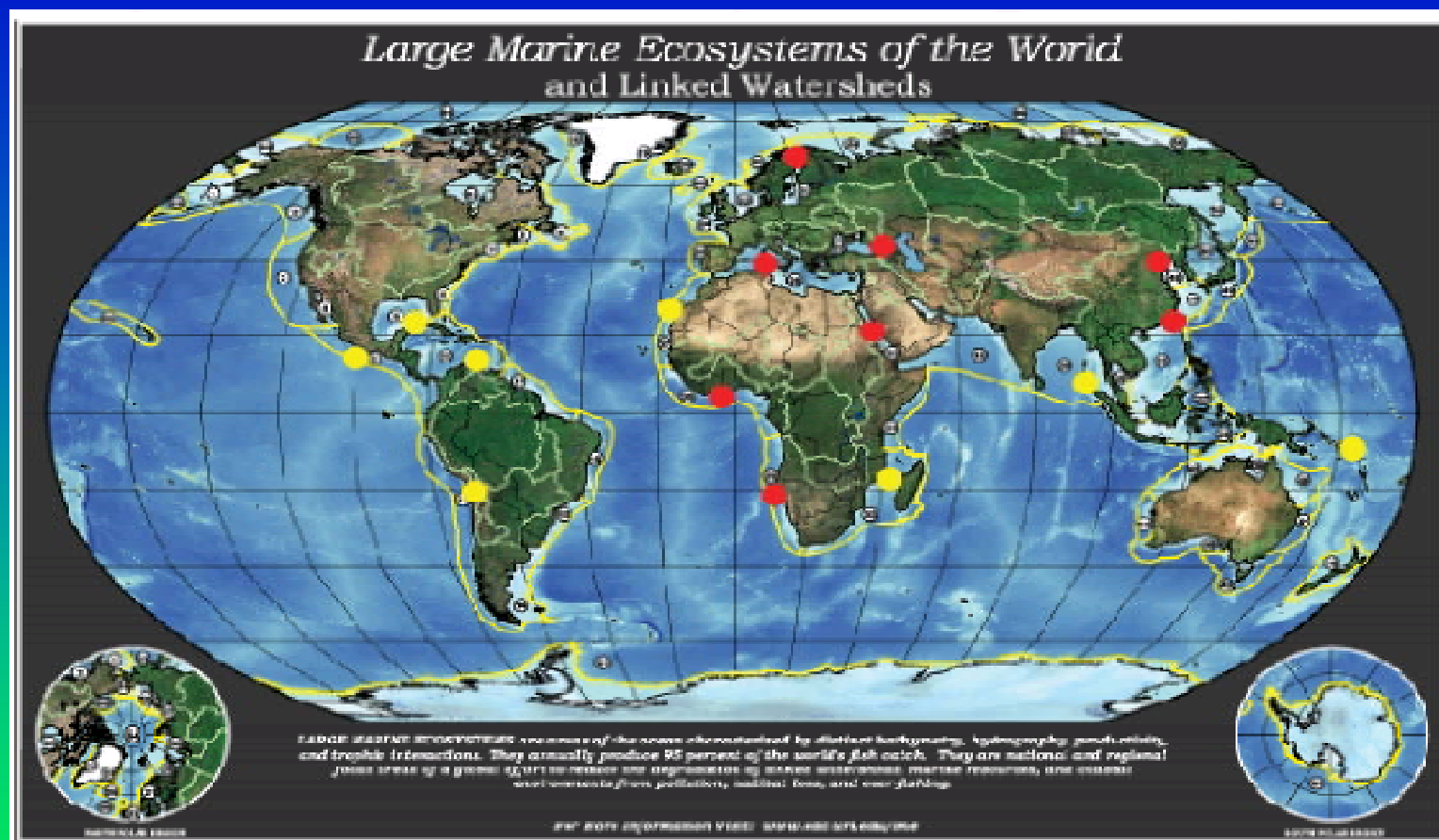


### GOVERNANCE MODULE INDICATOR

Stakeholder participation  
Adaptive management

## GEF/LME Projects

- In preparation
- Approved



- |                                     |                         |                           |  |                      |
|-------------------------------------|-------------------------|---------------------------|--|----------------------|
| 1 East Bering Sea                   | 14 Palagonian Shelf     | 27 Canary Current         | 40 Northeast Australian Shelf-Great Barrier Reef | 52 Okhotsk Sea       |
| 2 Gulf of Alaska                    | 15 South Brazil Shelf   | 28 Guinea Current         | 41 East-Central Australian Shelf                 | 53 West Bering Sea   |
| 3 California Current                | 16 East Brazil Shelf    | 29 Benguela Current       | 42 Southeast Australian Shelf                    | 54 Chukchi Sea       |
| 4 Gulf of California                | 17 North Brazil Shelf   | 30 Agulhas Current        | 43 Southwest Australian Shelf                    | 55 Beaufort Sea      |
| 5 Gulf of Mexico                    | 18 West Greenland Shelf | 31 Somali Coastal Current | 44 West-Central Australian Shelf                 | 56 East Siberian Sea |
| 6 Southeast U.S. Continental Shelf  | 19 East Greenland Shelf | 32 Arabian Sea            | 45 Northwest Australian Shelf                    | 57 Laptev Sea        |
| 7 Northeast U.S. Continental Shelf  | 20 Barents Sea          | 33 Red Sea                | 46 New Zealand Shelf                             | 58 Kara Sea          |
| 8 Scotian Shelf                     | 21 Norwegian Shelf      | 34 Bay of Bengal          | 47 East China Sea                                | 59 Iceland Shelf     |
| 9 Newfoundland-Labrador Shelf       | 22 North Sea            | 35 Gulf of Thailand       | 48 Yellow Sea                                    | 60 Faroe Plateau     |
| 10 Insular Pacific-Hawaiian         | 23 Baltic Sea           | 36 South China Sea        | 49 Kuroshio Current                              | 61 Antarctic         |
| 11 Pacific Central-American Coastal | 24 Celtic-Biscay Shelf  | 37 Sulu-Celebes Sea       | 50 Sea of Japan                                  | 62 Black Sea         |
| 12 Caribbean Sea                    | 25 Iberian Coastal      | 38 Indonesian Sea         | 51 Oyashio Current                               | 63 Hudson Bay        |
| 13 Humboldt Current                 | 26 Mediterranean Sea    |                           |  | 64 Arctic Ocean      |

# **INDICATORS OF CHANGING ECOSYSTEM STATES:**

**Productivity**

**Fish and Fisheries**

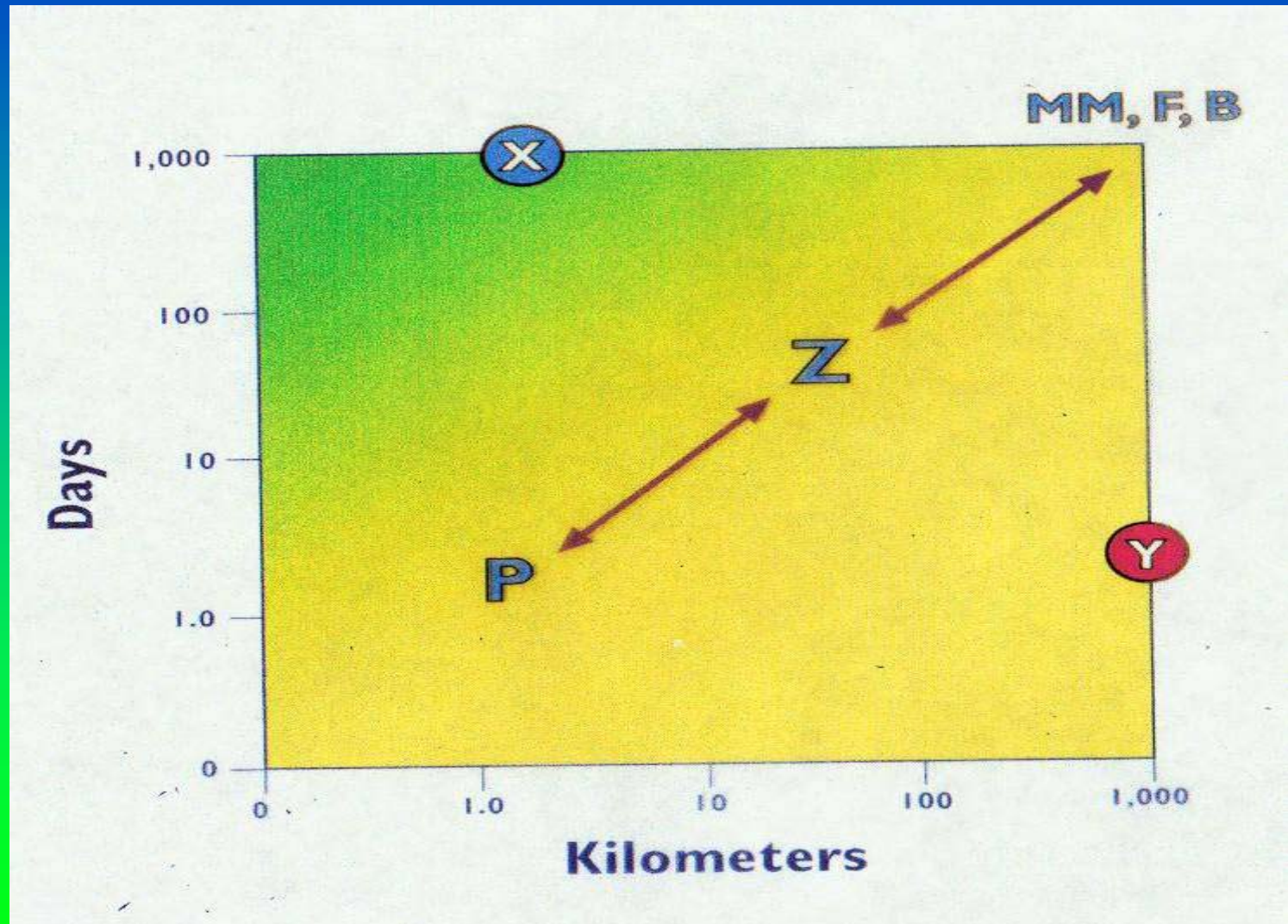
**Pollution**

**Socioeconomic**

**Governance**



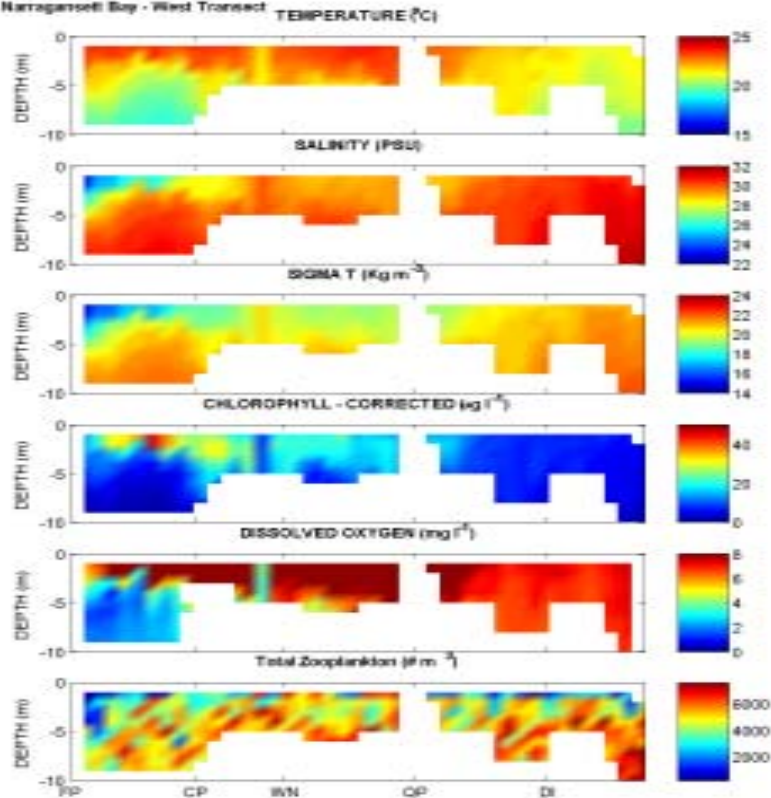
# TEMPORAL AND SPATIAL SCALE RELATIONS FOR SELECTED INDICATORS



# PRODUCTIVITY INDICATORS:

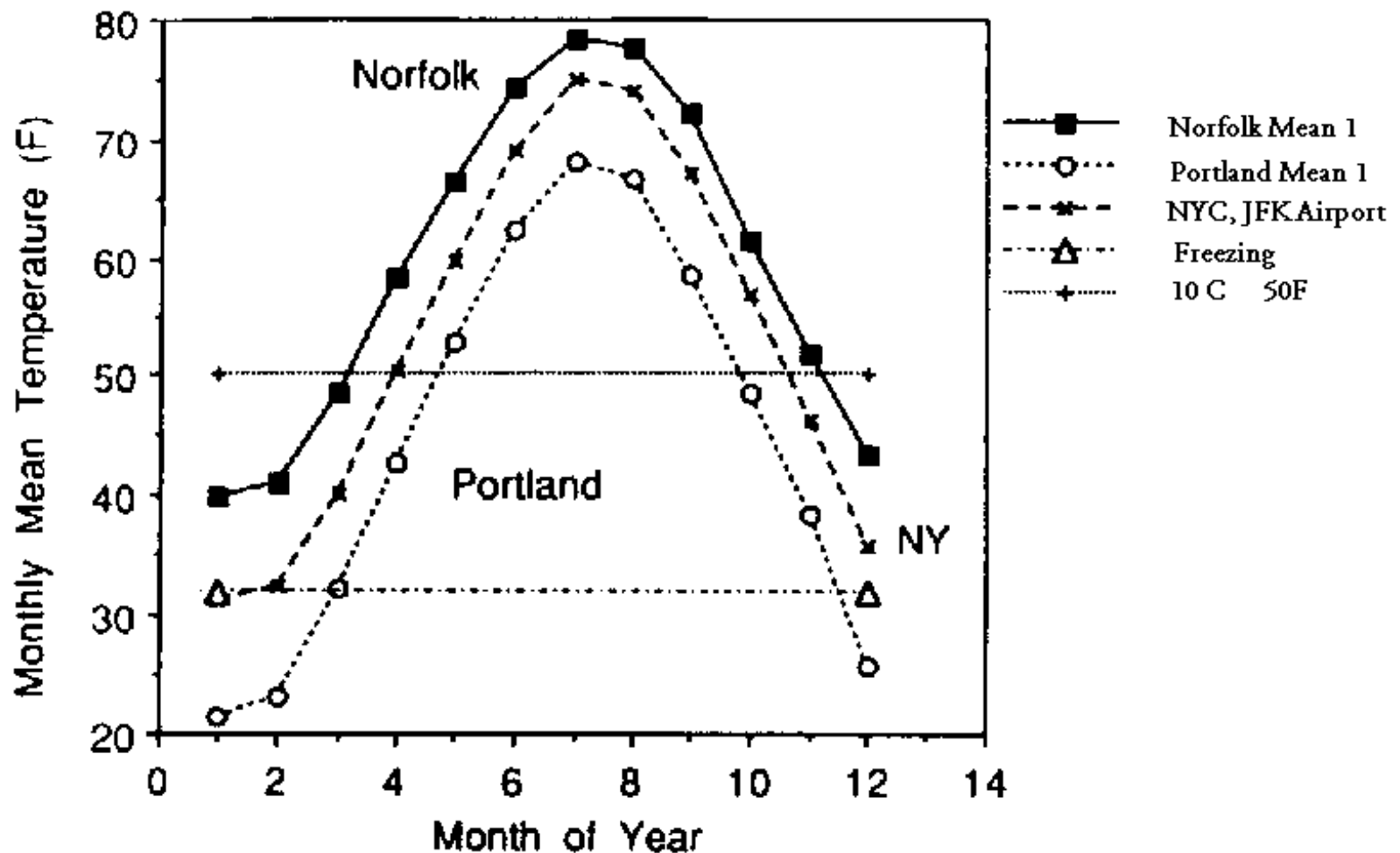
- Primary productivity ( $\text{gc}/\text{m}^2/\text{y}^1$ )
- Chlorophyll *a* ( $\mu\text{g}/\text{l}$ )
- SST; water column temperature
- Photosynthetically active radiation (PAR)
- Nitrogen
- Zooplankton biomass ( $\text{cc}/100\text{m}^3$ )
- Zooplankton biodiversity ( $\text{n}/100\text{m}^3$ )

August 16, 2001  
Narragansett Bay - West Transect



An undulating oceanographic recorder (above), towed behind a ship, is used to collect ecological parameters needed to assess the state of the marine ecosystem (left).

# Northeast Shelf Meteorology

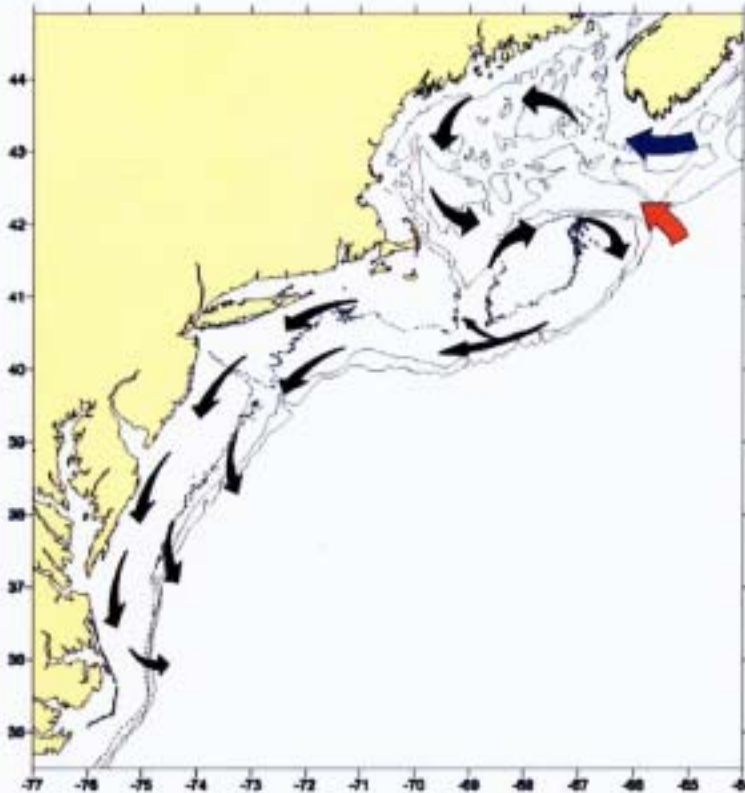


# Climate Drivers of the Northeast Shelf Ecosystem

- Warm Gulf Stream waters
- Cold Scotian Shelf incursions
- Winter North American cold air
- Warm Gulf of Mexico air
- Position of westerly North American jet air stream

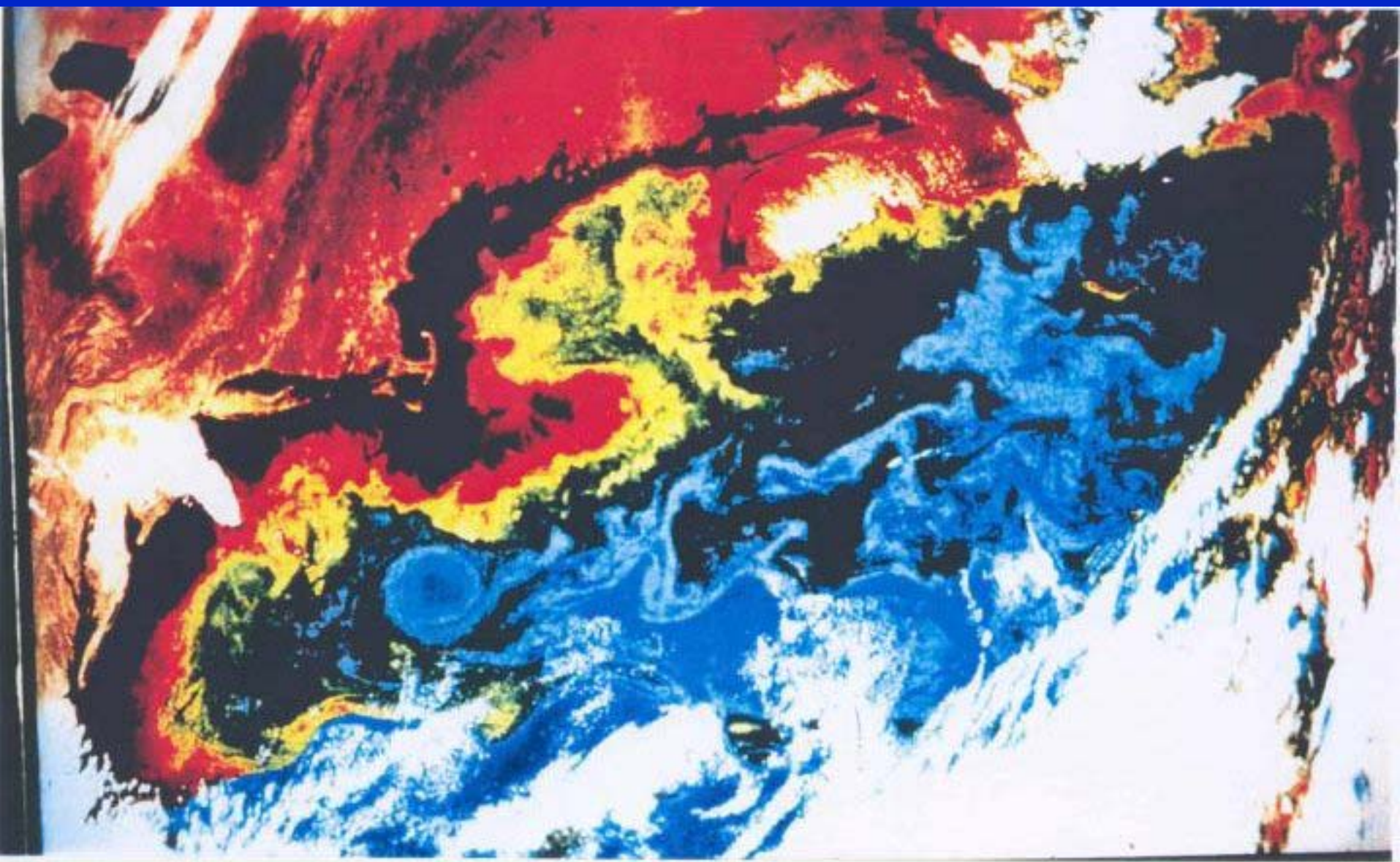
from O. Hertzman, 1996

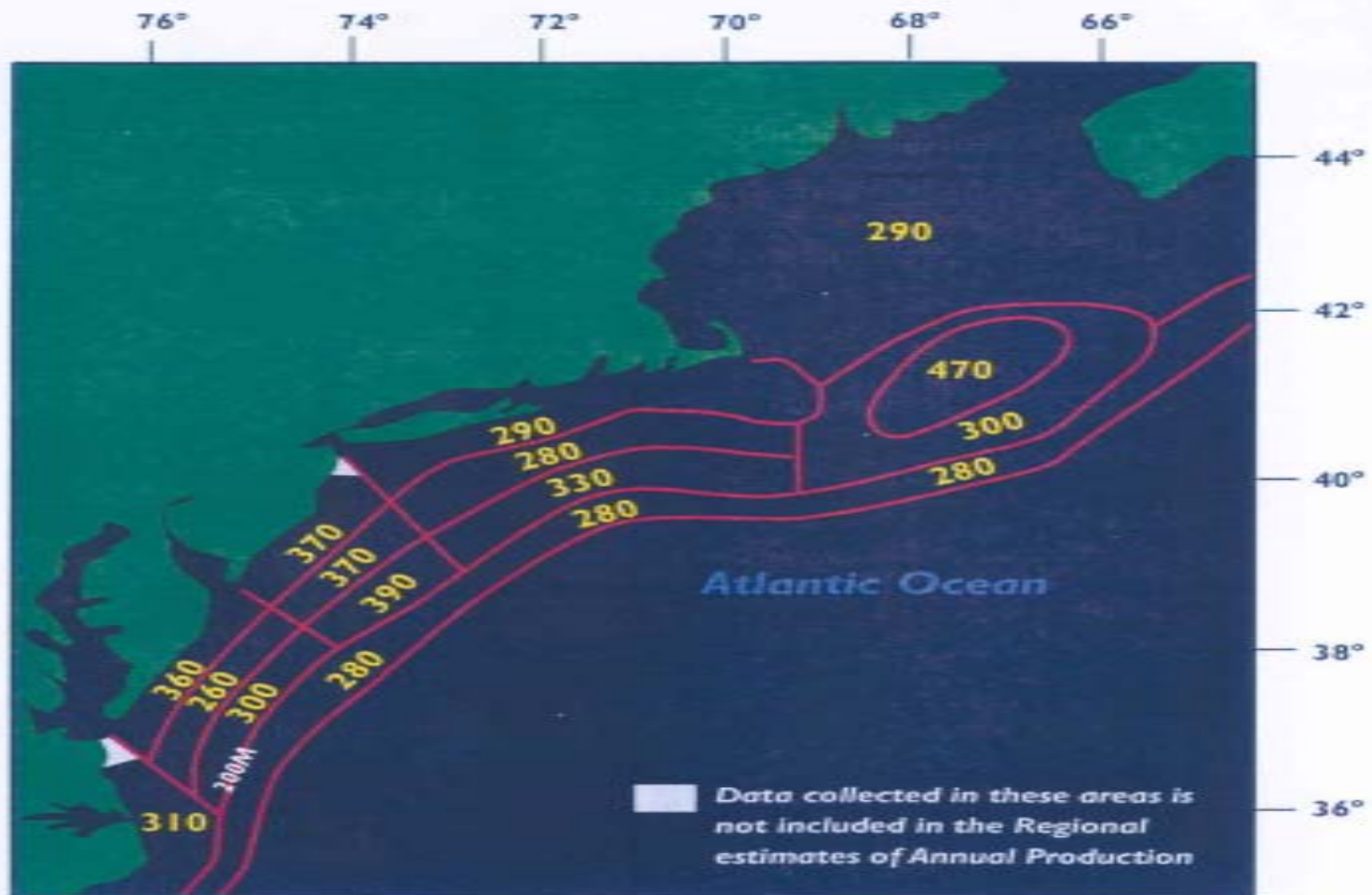




# General Circulation of the Northeast Shelf Ecosystem







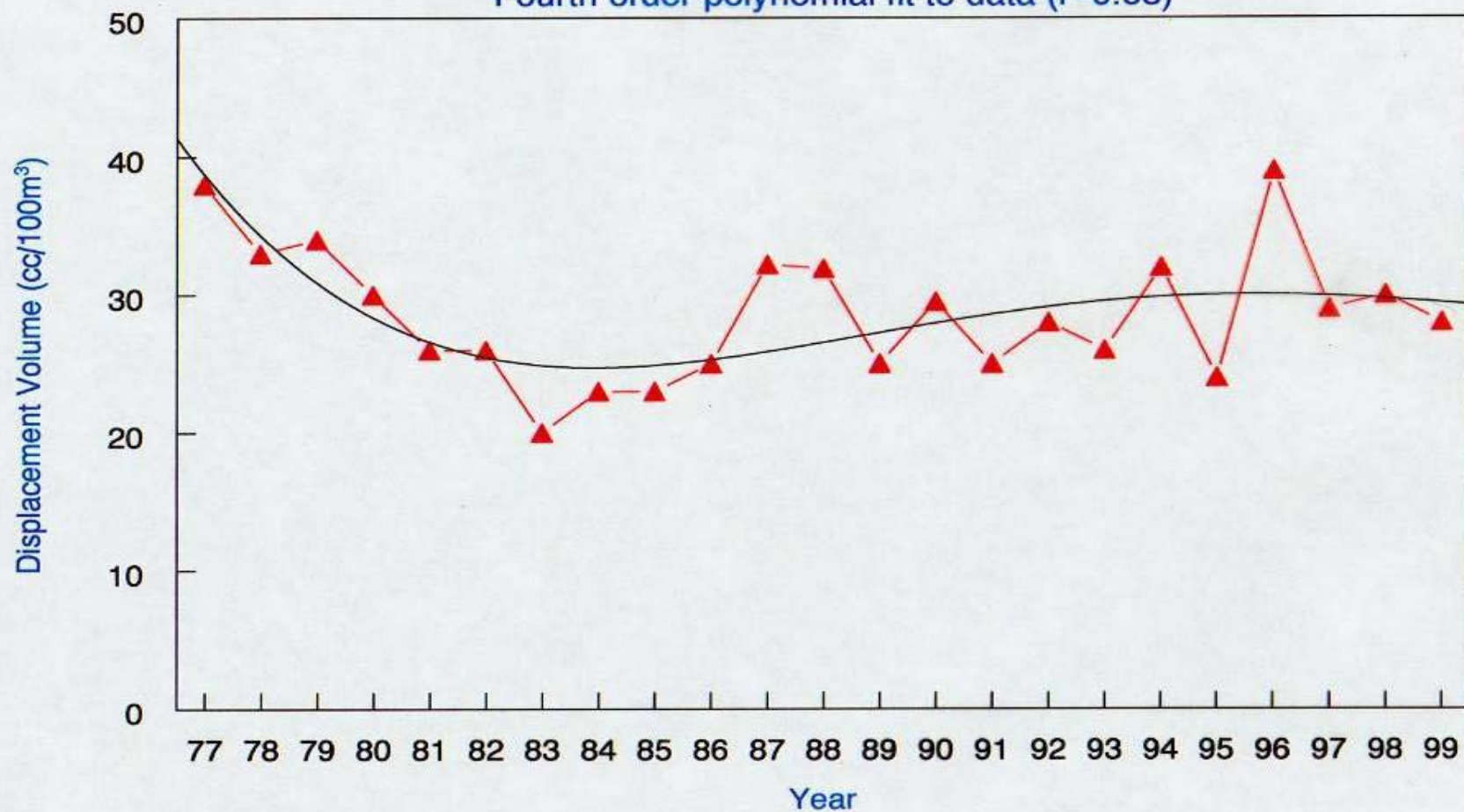
Estimates of annual phytoplankton primary production by region  
(particulate + dissolved organic carbon);  $\text{gC m}^{-2} \text{y}^{-1}$

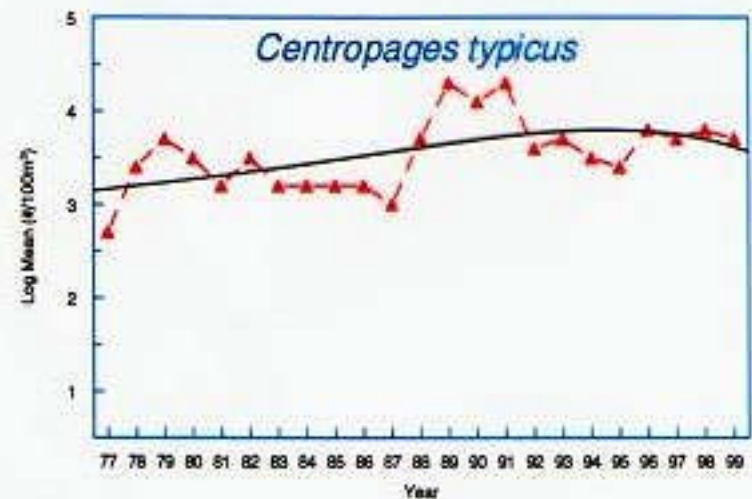
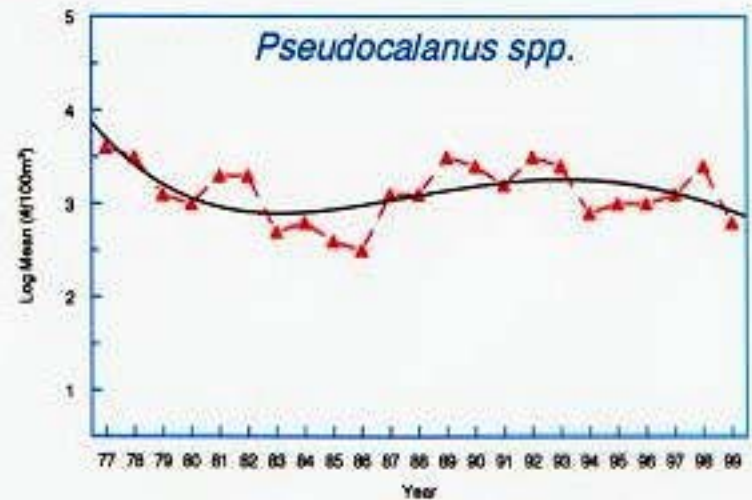
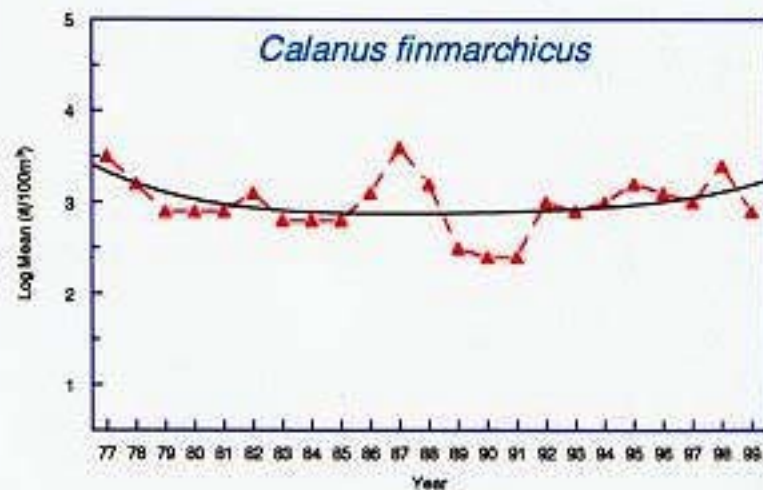
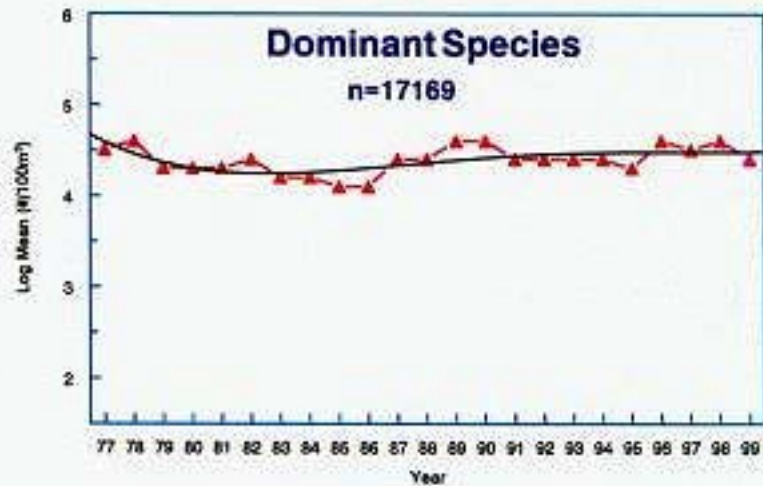


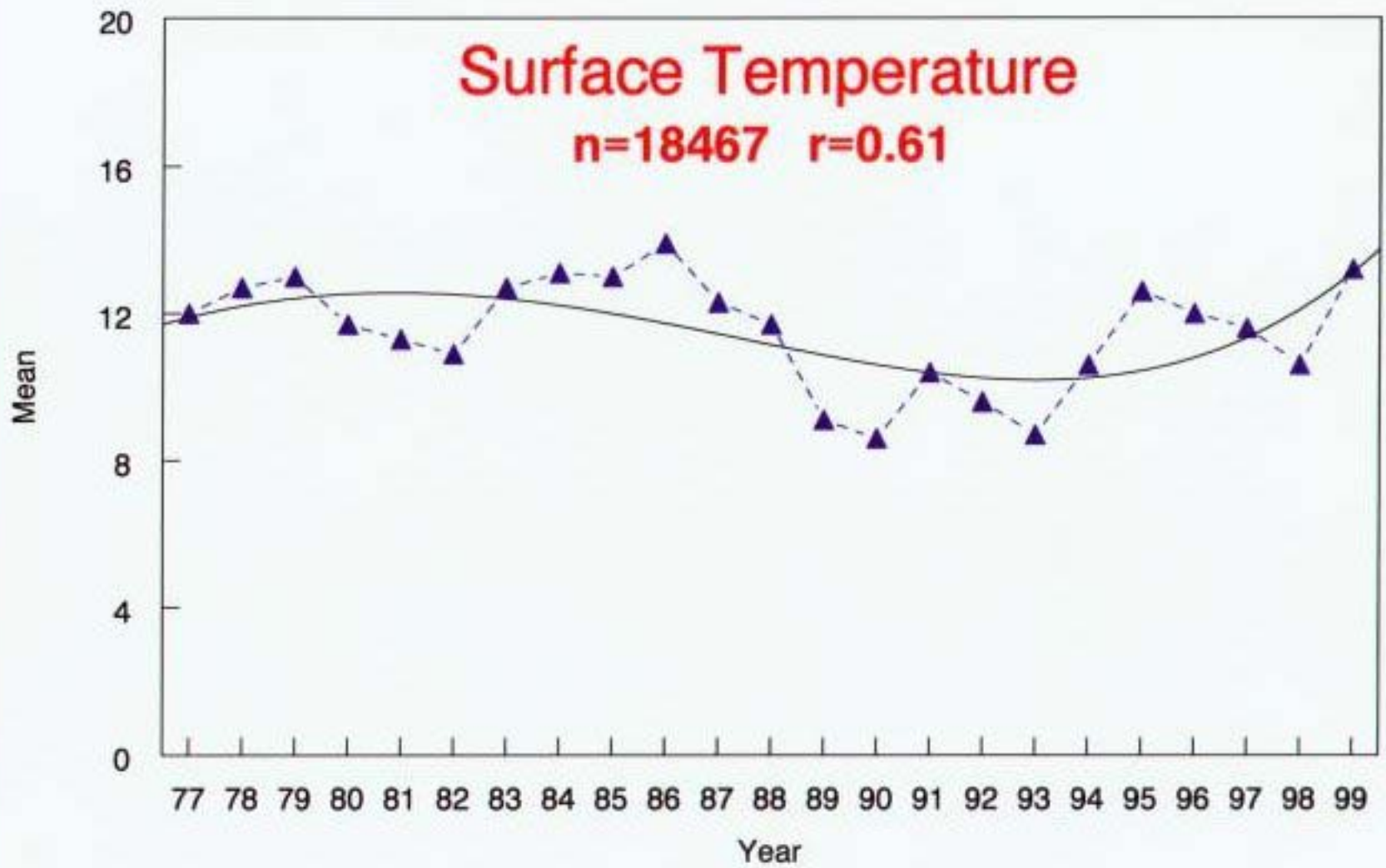
# U.S. Northeast Shelf Ecosystem

## Annual Median Zooplankton Biomass 1977 - 99

Fourth order polynomial fit to data ( $r=0.68$ )







# **FISH AND FISHERIES INDICATORS**

- **Demersal species surveys**
- **Pelagic species surveys**
- **Ichthyoplankton surveys**
- **Invertebrate surveys (clams, scallops, shrimp, lobster, squid)**
- **Essential fish habitat**
- **Marine protected areas**

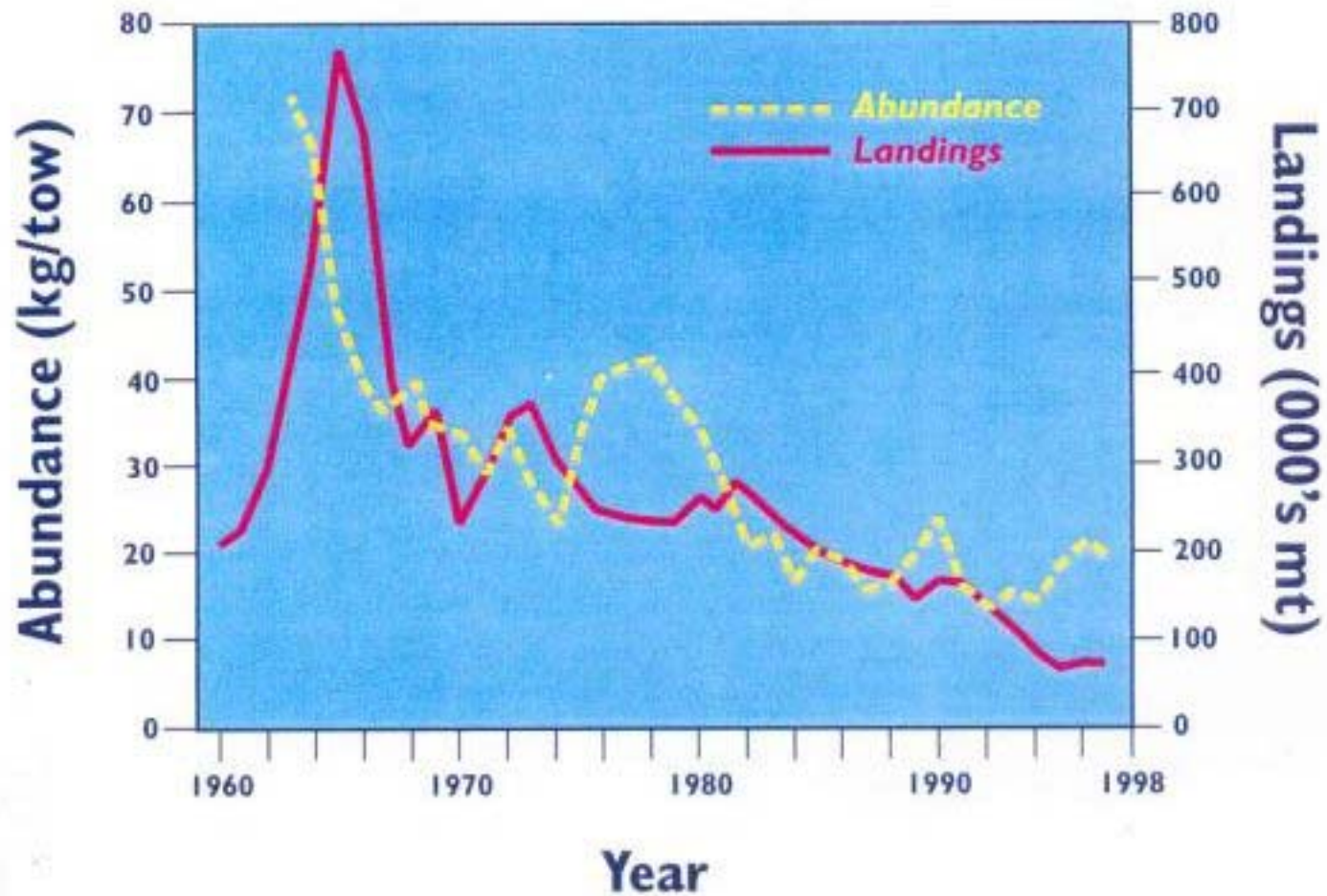


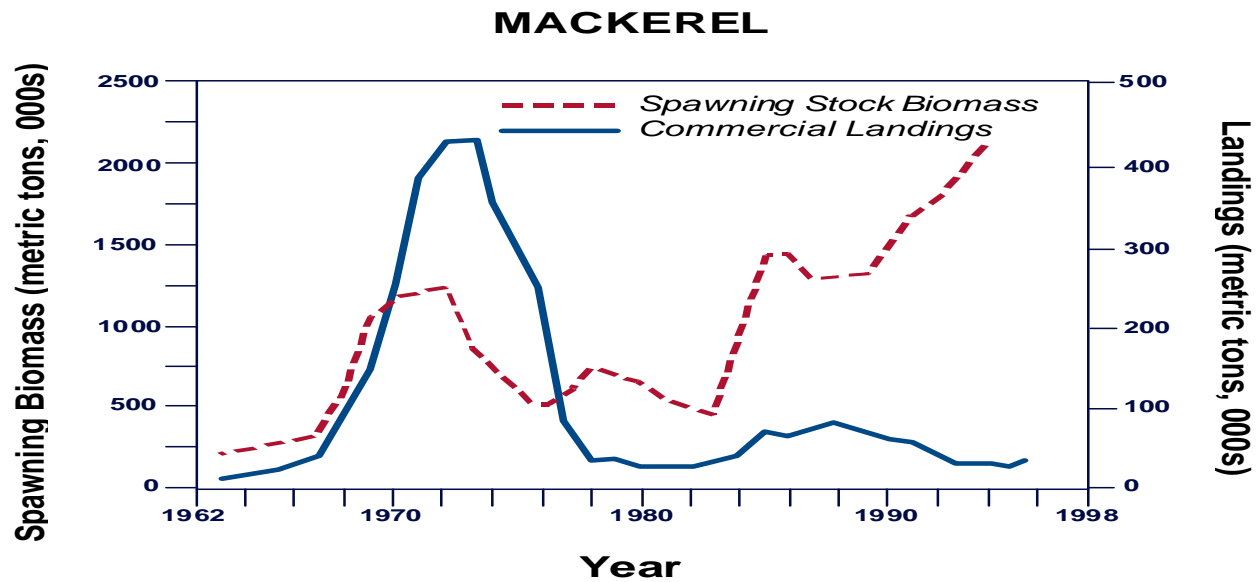
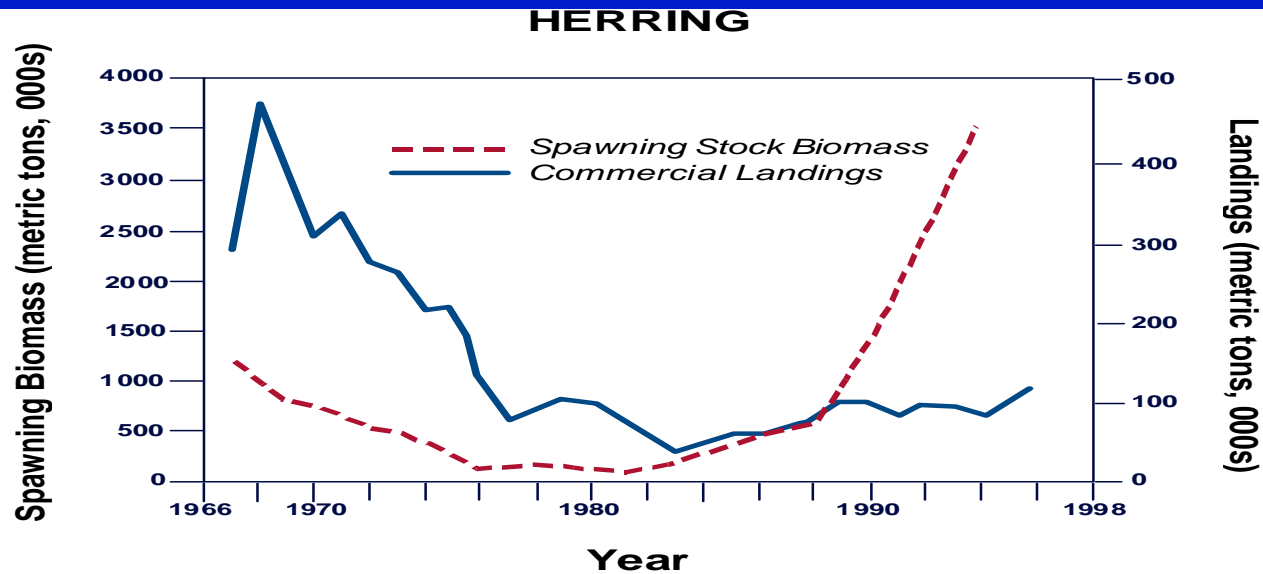
# **COMMON TERMS**

## **from Our Living Oceans Report**

- **Recent average yield (RAY)**
- **Current potential yield (CPY)**
- **Long term potential yield (LTPY)**
- **Stock level relative to LTPY**
- **Status of resource utilization**
- **Threatened or endangered**
- **Potential biological removal (PBR / MMPA)**

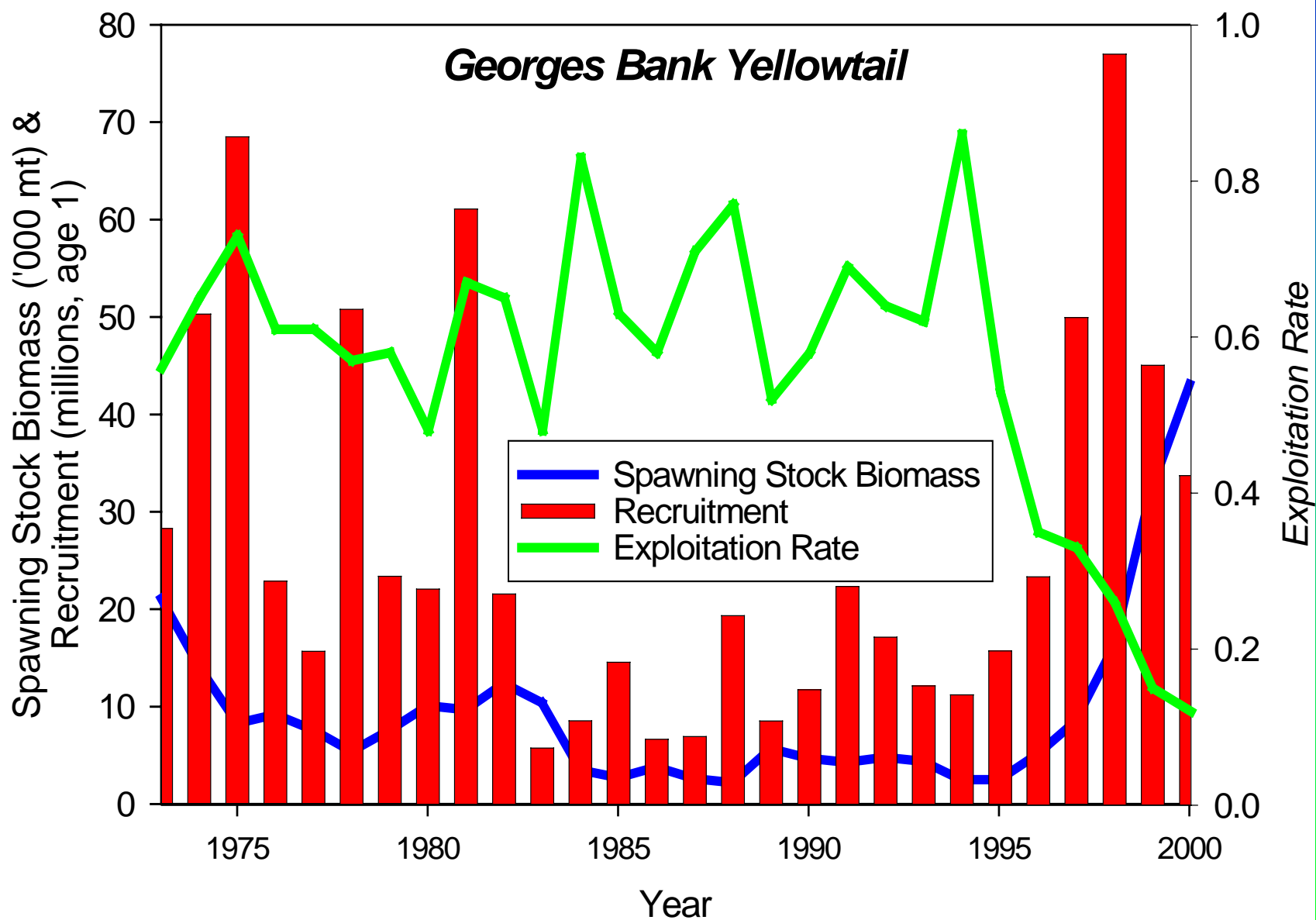
## PRINCIPAL GROUNDFISH & FLOUNDERS

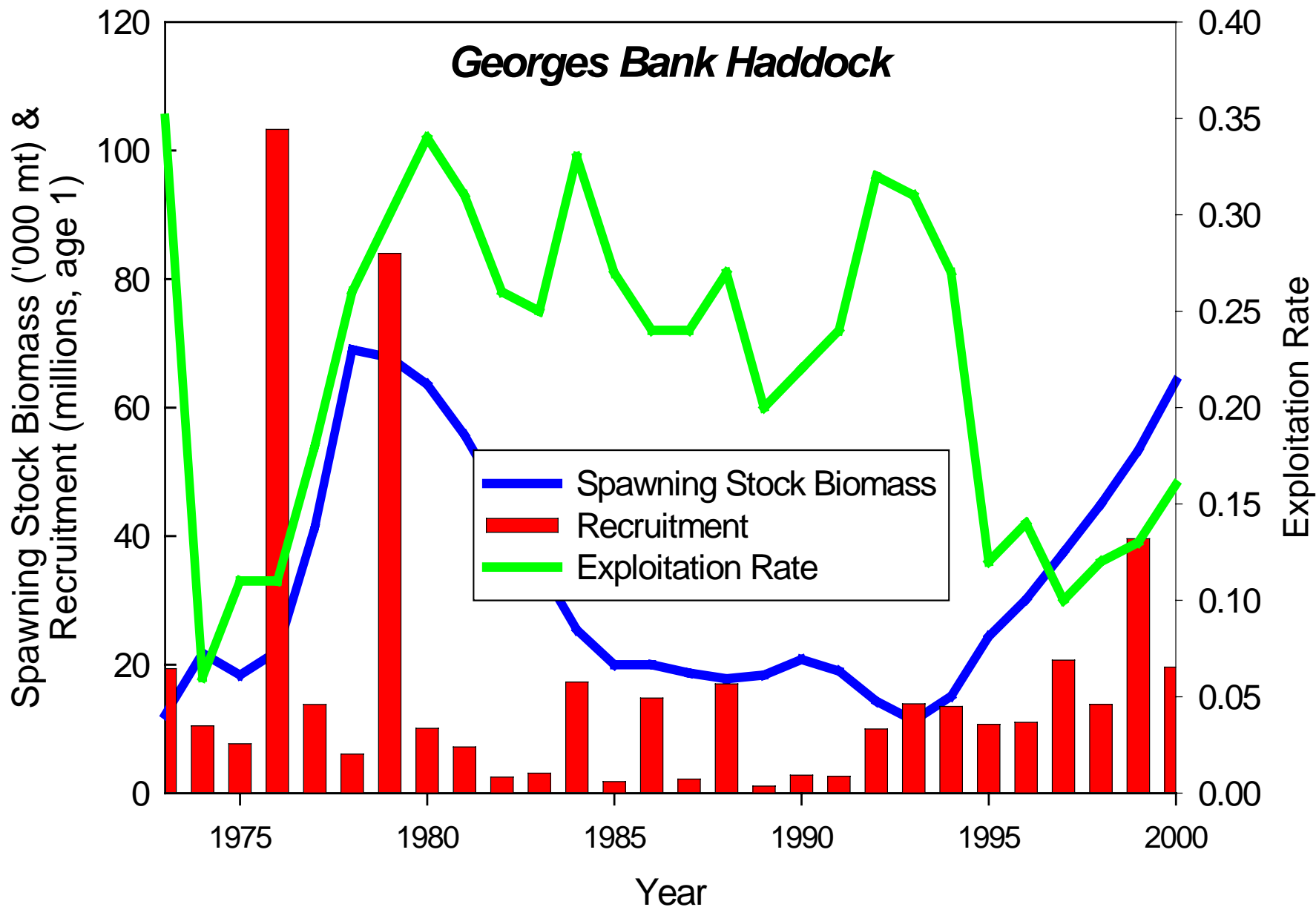


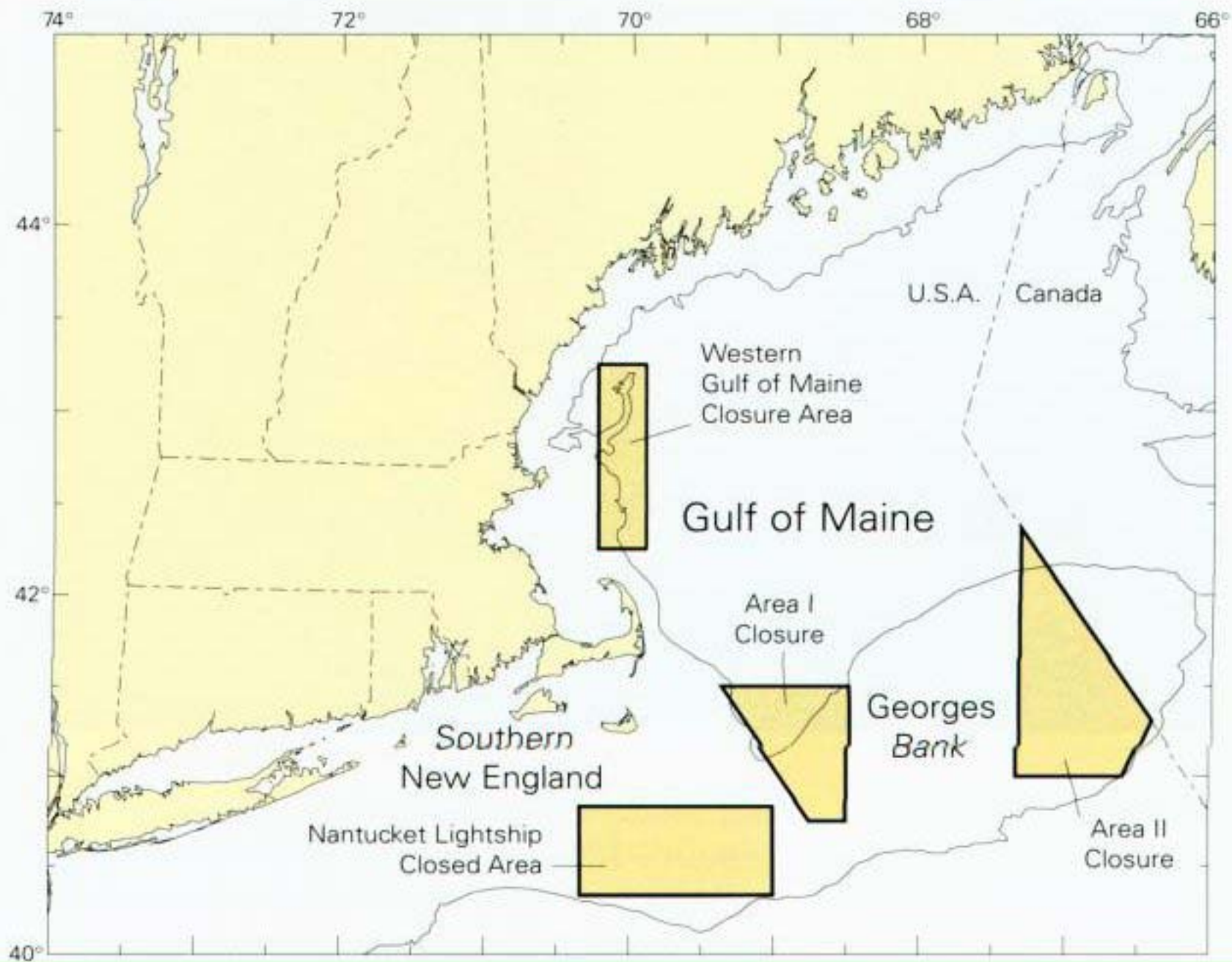


**Figure 6-8.** Top - Atlantic herring commercial landings and spawning stock biomass, 1967 through 1996 (thousand metric tons). Bottom - Atlantic mackerel landings and spawning stock biomass, 1963 through 1996 (thousand metric tons).

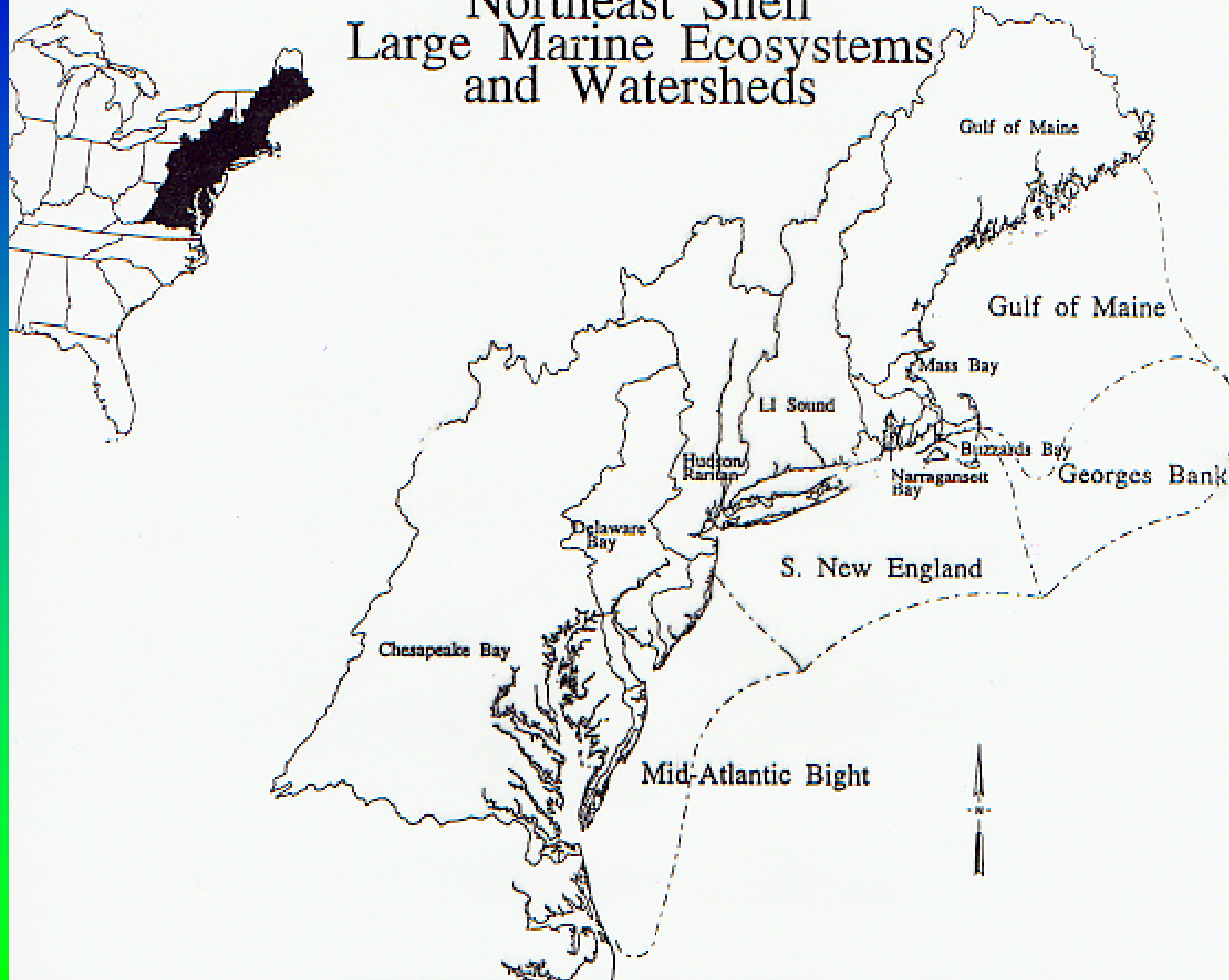
## Georges Bank Yellowtail







# Northeast Shelf Large Marine Ecosystems and Watersheds





# **POLLUTION AND ECOSYSTEM HEALTH INDICATORS**

## **Indicators:**

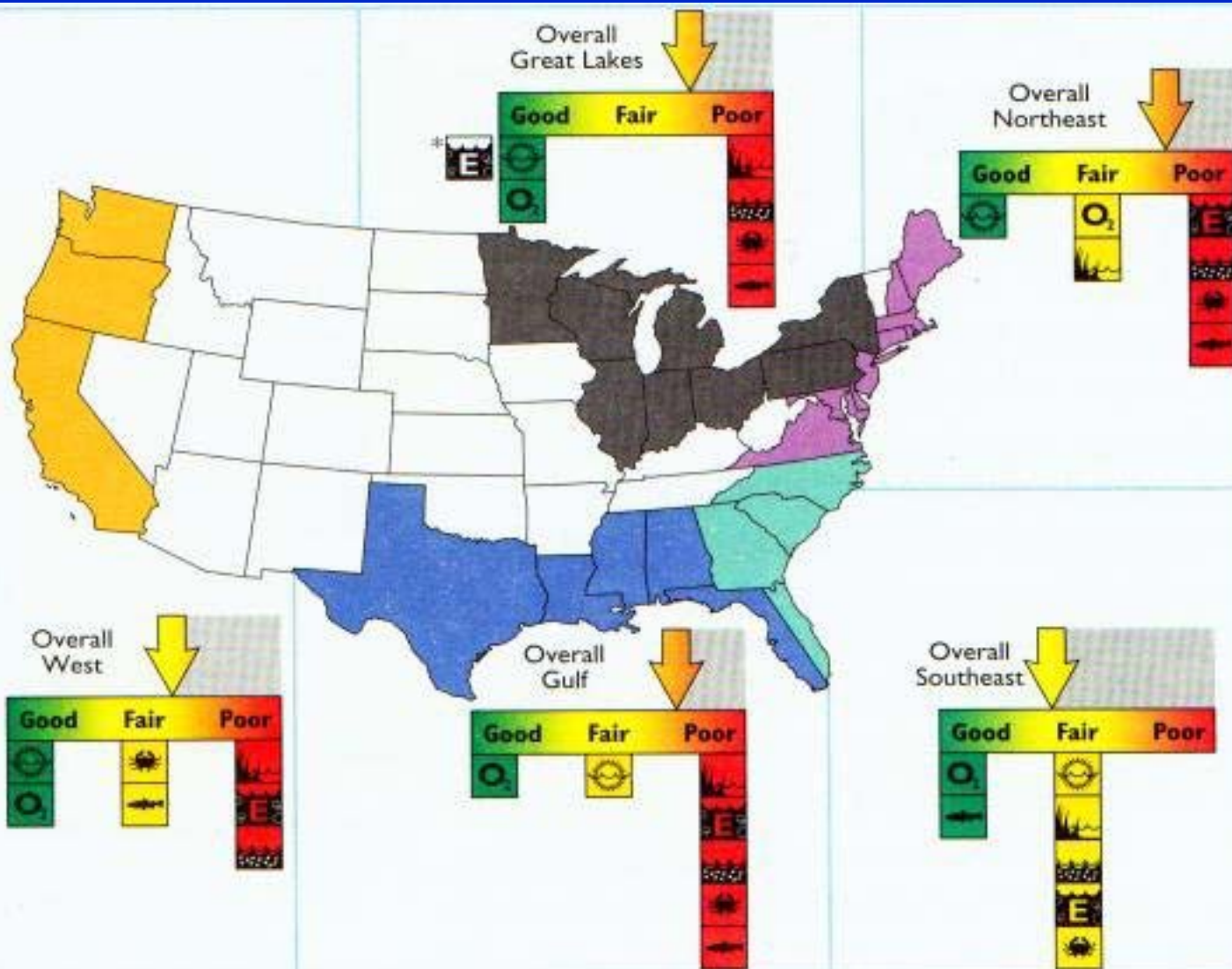
- Water Clarity**
- Dissolved Oxygen**
- Coastal Wetland Loss**
- Eutrophic Condition**
- Sediment Contamination**
- Benthic Index**
- Fish Tissue Contaminants**
- Multiple Marine Ecological Disturbances**

## Overall National Coastal Condition



### Ecological Health

- Water Clarity
- Dissolved Oxygen<sup>\*\*</sup>
- Coastal Wetlands
- Eutrophic Condition
- Sediment
- Benthos
- Fish Tissue

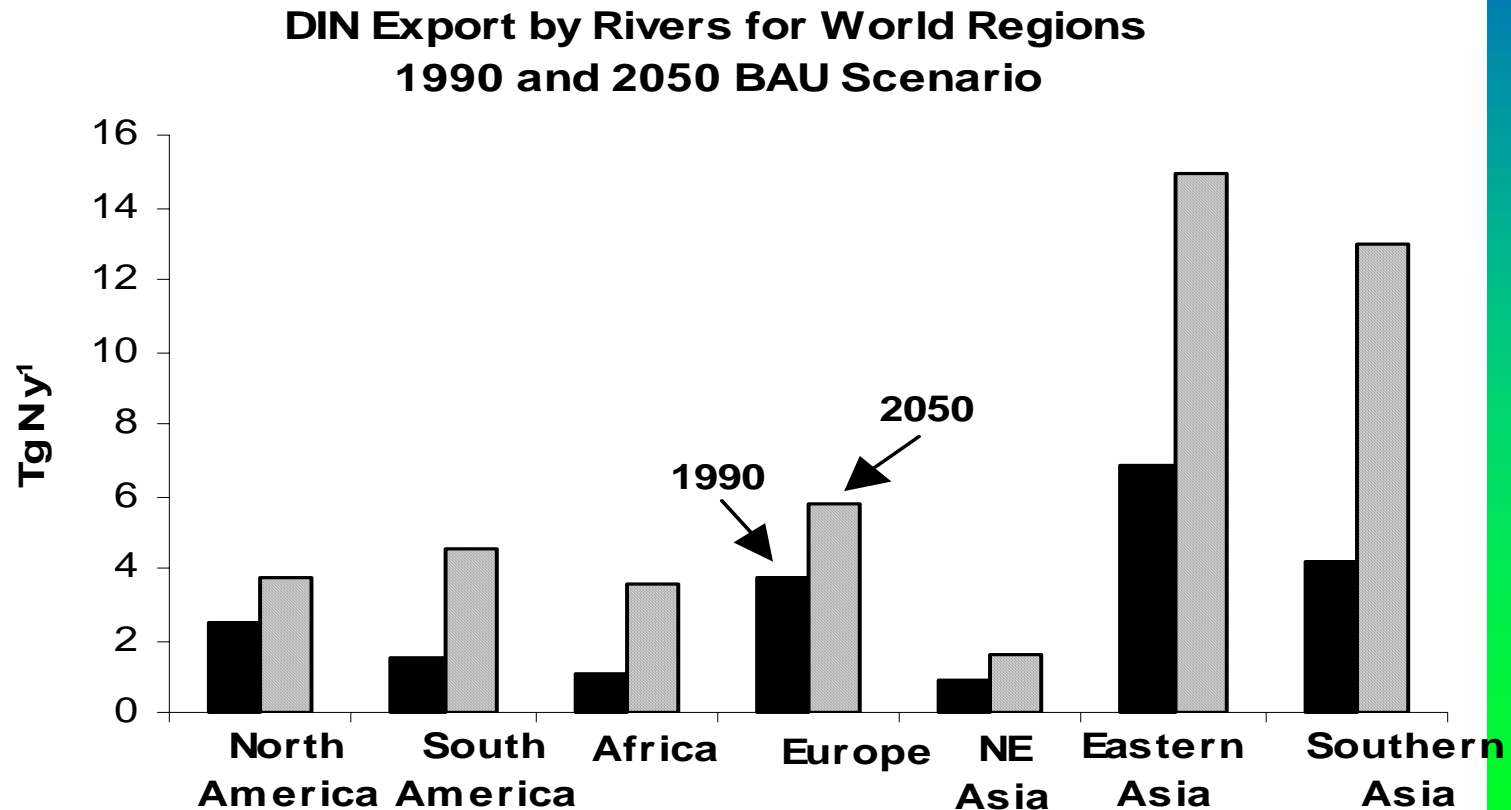


\* No indicator data available.

\*\* Does not include the hypoxic zone in offshore Gulf of Mexico waters.

**Figure 2-1.** Overall national coastal condition.

# Model-predicted nitrogen (dissolved inorganic N) export by rivers to coastal systems in 1990 and 2050

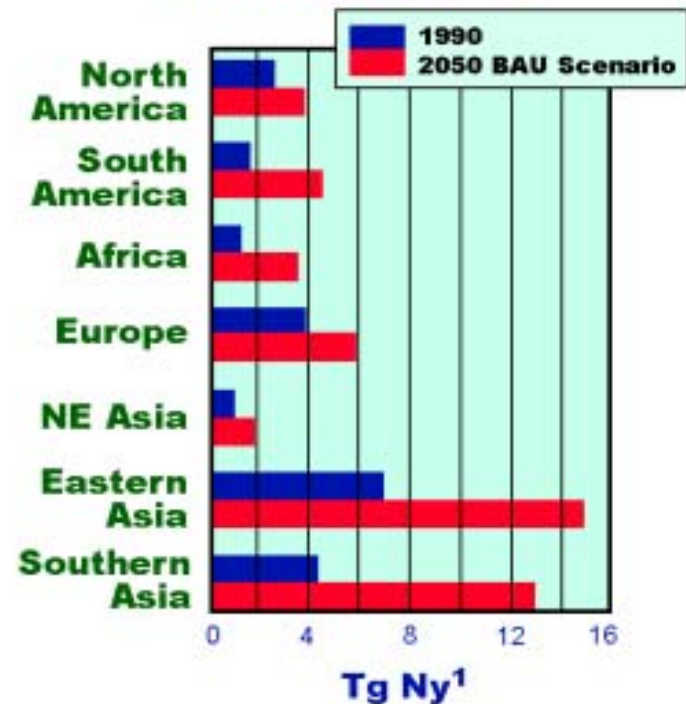


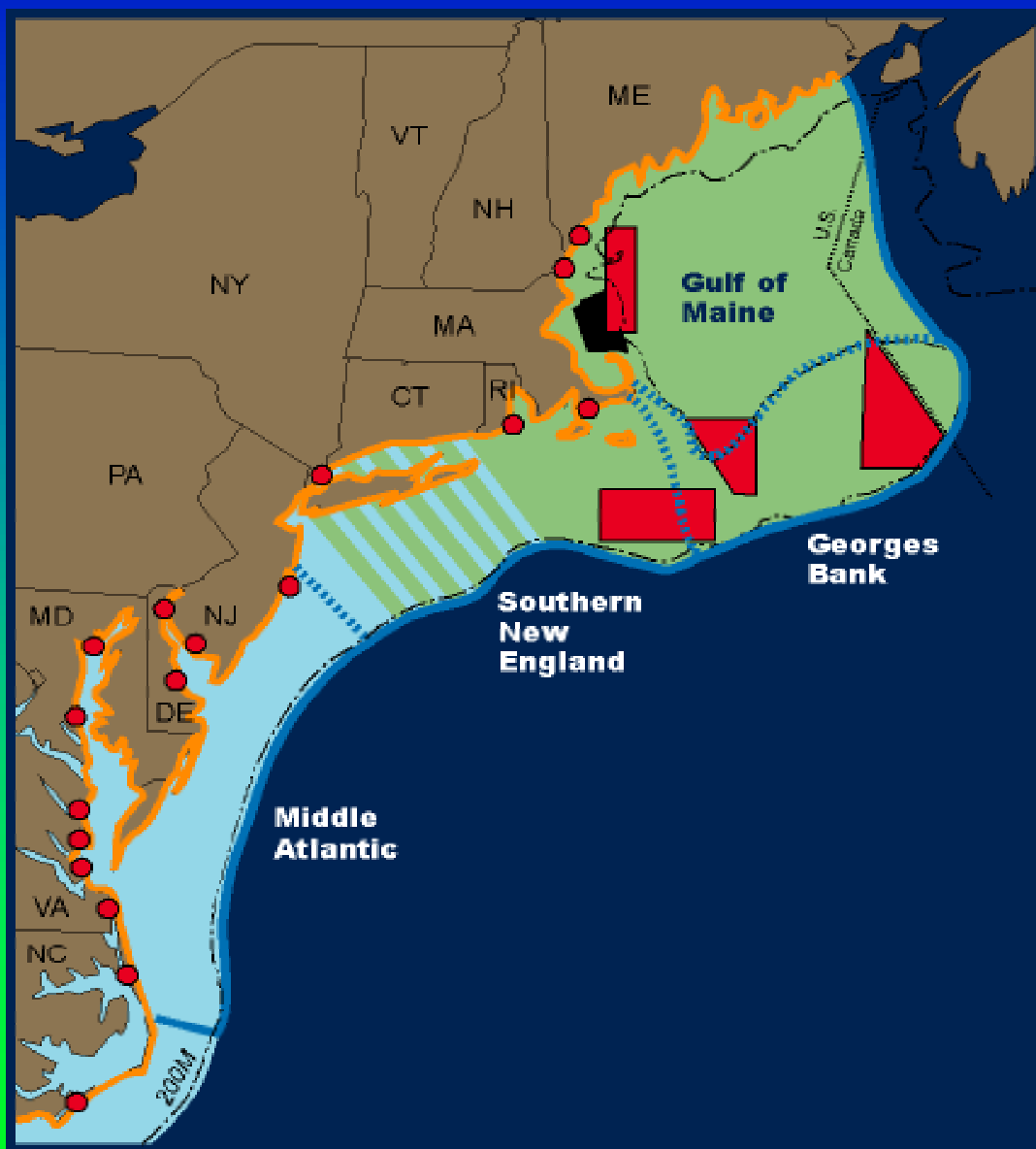
## Dead Zone of the Gulf of Mexico LME



The Dead Zone reached a record high of 7,728 square miles in 1999

## DIN Export by Rivers for World Regions





## Examples of Management Jurisdictions of the Northeast Shelf Ecosystem

- New England Fishery Management Council Region
- Mid Atlantic Fishery Management Council Region
- Shared Jurisdiction
- Northeast U.S. Continental Shelf LME
- LME Subdivisions
- Marine Protected Areas (Fisheries)
- Stellwagen Bank National Marine Sanctuary
- Coastal Condition Assessments
- NERRS Locations

# ECOSYSTEM MANAGEMENT: A PARADIGM SHIFT

FROM	TO
Individual species	Ecosystems
Small spatial scale	Multiple scales
Short-term perspective	Long-term perspective
Humans: independent of ecosystems	Humans: integral part of ecosystems
Management divorced from research	Adaptive management
Managing commodities	Sustaining production potential for goods and services

NOTE: Some of the substantive changes between traditional resource management and ecosystem management.

**PLANNING ACTIONS**

**1. Transboundary Diagnostic Analysis (TDA)** – provides consensus priorities from analysis and ranking of water-related resourcesissues, their environmental and socioeconomic impacts, immediate and root causes and possible remedies

**2. Strategic Action Program (SAP)** – provides national and regional commitments to policy, legal and institutional reforms, and investments to remedy root causes of priority transboundary issues identified in TDA

**IMPLEMENTATION ACTIONS**

**3. Ecosystem-based assessment and management strategy for TDA and SAP**

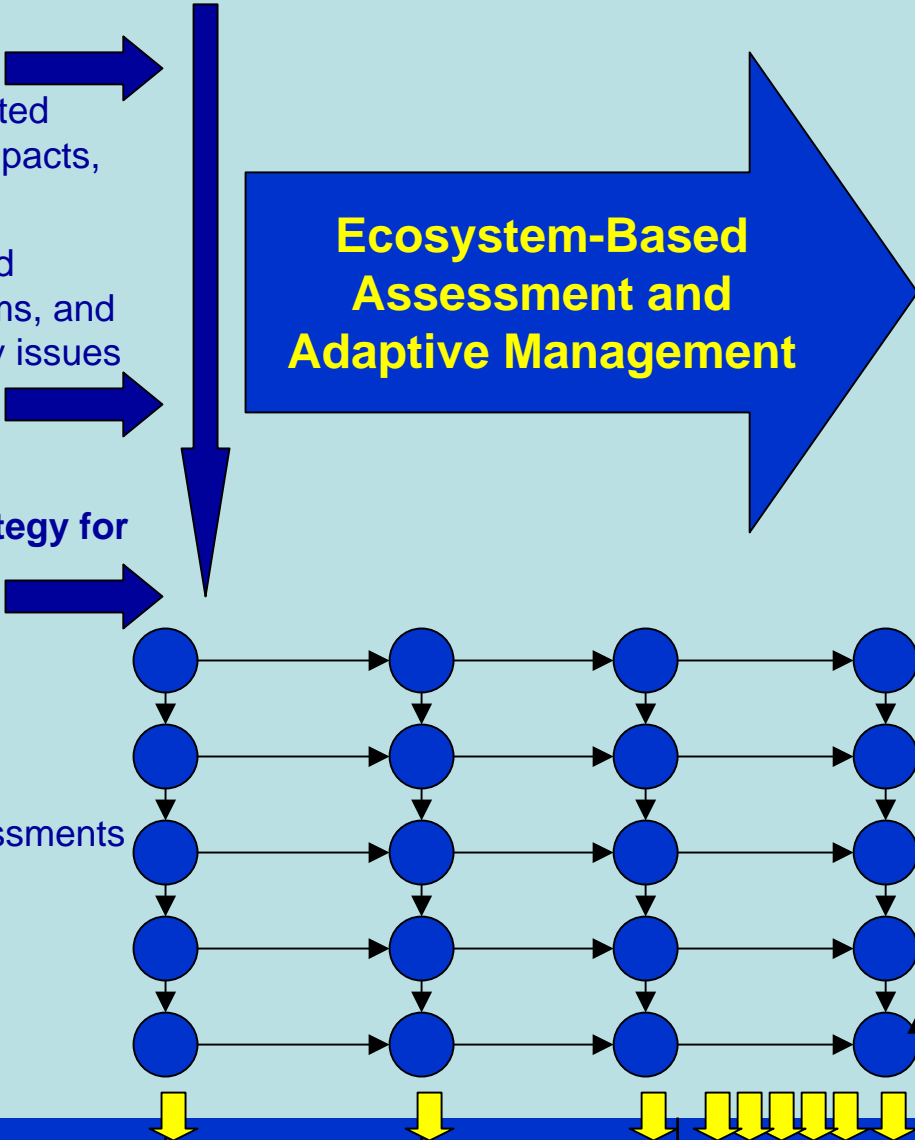
3.1 Productivity indicators and assessments

3.2 Fish and fisheries indicators and assessments

3.3 Pollution and ecosystem health indicators and assessments

3.4 Socioeconomic indicators and assessments

3.5 Governance indicators and assessments

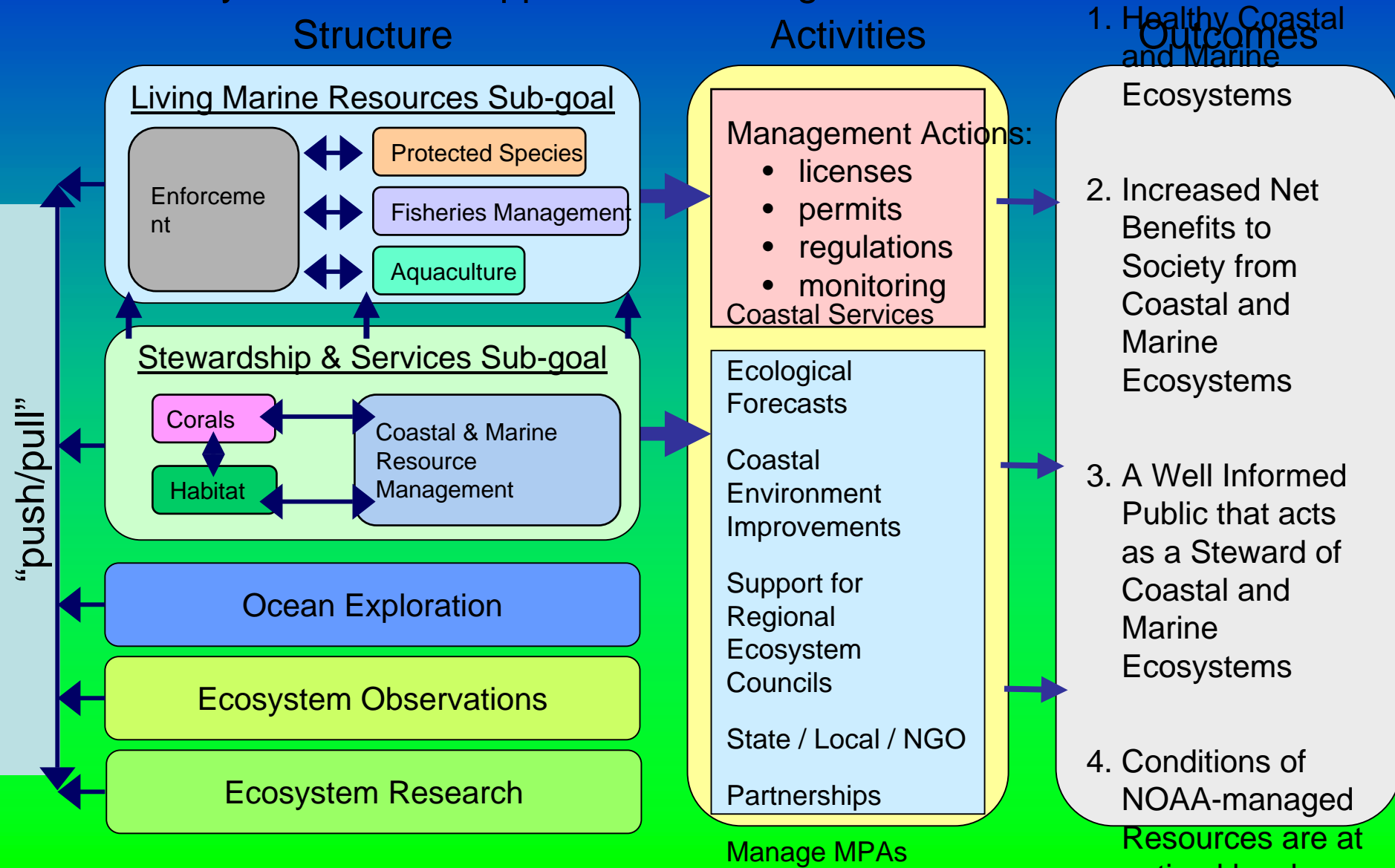


Year 1	Year 2	Year 3	Year 4	Years 5-10
	Assessments & Management Actions	Assessments & Management Actions	Assessments & Management Actions	Toward Self-financing Assessments and adaptive management



# Ecosystems (Working Structure)

Ecosystems-based approach to management of marine resources



# Volumes of Peer Reviewed Published LME Case Studies

<b>AAAS</b>	<b>5</b>
<b>Blackwell Science</b>	<b>4</b>
<b>Elsevier Science</b>	<b>4</b>

**[www.lme.noaa.gov](http://www.lme.noaa.gov)**